UNIVERSITY OF BRISTOL.

THE ANNUAL REPORT

OF THE

Agricultural and Horticultural Research Station

(*THE NATIONAL FRUIT AND CIDER INSTITUTE*)

LONG ASHTON, BRISTOL,

1932.

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In Memoriam.

HENRY BURROUGHES NAPIER.

By the death of Henry Burroughes Napier in the closing days of 1932, many bodies in the West of England connected with the land, and the Bath and West Society in particular, have sustained the loss of one of their most active supporters and an outstanding authority on agriculture and kindred subjects. Probably none of those bodies owe so much to the activities of one individual as the National Fruit and and Cider Institute does to him. It is outside the writers' province to review the valuable work which he achieved in his widely varied public life, but a close personal association extending over a period of almost thirty years in connection with the work of the Institute permits them to place on record a brief review of his services in the development of an undertaking which—now become an Imperial research centre—might not have survived its first few struggling years, had it not been for his efforts on its behalf.

As a member of the Council of the Bath and West Society at the beginning of the present century Mr. Napier was already in touch with the activities of the Society in promoting research in the subject of cider making. At that time the experimental work was centred at Butleigh Court, facilities at which were provided by Mr. R. Neville Grenville for the period of ten years over which the Society's experiments extended. At the end of that time, in 1902, steps were taken to establish the work on a more extended and permanent basis. The negotiations leading up to a successful issue in 1903 were in the hands of the late Mr. A. E. Brooke-Hunt, one of the officials of the Board of Agriculture and Fisheries, and were recorded by him in the pages of the Bath and West Journal for 1903-4. Their outcome, a tribute to his own genius for organisation, was the decision to form a National Fruit and Cider Institute at which should be centred the investigations on cider making and an amplified programme of research embracing the study and culture of cider apples and extending to the subject of fruit culture in general. In support of the new venture financial assistance in the form of annual grants was promised by the Society, the Board of Agriculture and the County Councils of Devon, Gloucester,

Hereford, Monmouth, Somerset and Worcester. A provisional organising Committee was appointed, and one of its first tasks was to find a suitable location for the Institute.

It was at this stage that Mr. Napier first came into intimate contact with the scheme. The Committee decided that somewhere in the neighbourhood of Bristol would be the most central and appropriate place for the home of the work, and proceeded to search for a suitable spot. Mr. Napier, as agent for the Ashton Court Estate, which included a large area of the land on the south side of the City, was consulted. Ultimately through his good offices and personal interest, a plot of land at Long Ashton, 12 acres in extent with a few simple farm buildings and a cottage adjoining, was obtained on a lease from the Estate. This formed the nucleus of the present Research Station and was originally a part of Fenswood Farm. As the young Institute grew in strength further portions of this farm were rented, until ultimately at the conclusion of the war the whole farm of 260 acres was purchased. In the various transactions with the Estate associated with these developments the negotiations were greatly simplified and carried through without any serious difficulty owing to his determination to do all in his power to promote an undertaking with a potential sphere of usefulness which he recognised at the outset and grew more and more firmly to believe in as the years passed and the work expanded. He regarded its presence at the heart of the Estate which he served as a definite and valuable asset to the Estate and its agricultural tenants, and in his capacity as agent gave it all possible assistance.

Useful as was his help in that respect, it was not through this purely business relationship that his services to the Institute will be estimated. As soon as the preliminaries for the new venture were completed he was nominated by the Bath and West Society as one of its representatives on the Governing Body. The latter at once elected him a member of the Managing Committee and invited him to accept the office of Hon. Treasurer. This he did and continued to hold it uninterruptedly for 29 years till his death. He became Chairman of that Committee in 1906 and, later, Chairman of the Governing Body, both of which offices he retained till the end. Thus his association with the Institute extended from the beginning of its existence. In his important official capacity he was intimately concerned with every phase in the history of its development.

In 1912 the Institute became linked up with the University of Bristol, an association which resulted in the establishment by the University of the Department of Agriculture and Horticulture with its headquarters at Long Ashton. Control of the work there

then passed into the hands of the Agricultural Committee of the University, a specially constituted body to administer the affairs of the Department, composed jointly of the members of the Managing Committee of the Institute and nominees of the University. Mr. Napier's treasurership of the Institute was then extended to serve for the Department also : in addition he was elected Chairman of its Finance and Business Sub-Committee, a position which he retained continuously. After the war the Department was enlarged, firstly in 1922 by the acquisition of the Research Station for Fruit and Vegetable Preservation at Chipping Campden, which has now become the official centre for research on commercial canning, and later in 1924 by the establishment of the Agricultural Advisory Centre at Berkeley Square, Bristol. As treasurer of the Department he was faced with heavy additional calls upon his time as the result of these extensions. Nevertheless he undertook the increased responsibilities without demur and through his experienced guidance on the financial side and his wide and varied agricultural knowledge he contributed in no small degree to the remarkable and rapid success which has attended these new ventures.

In recognition of his long and devoted services to the University in connection with the Department and to the general advancement of agriculture and horticulture, the University conferred upon him the honorary degree of LL.D. in 1932, a distinction which he valued for its significance in respect of the subject as well as for its personal tribute.

Such a record of voluntary service might be left to speak for itself as to the measure of the loss which the Institute and the University have sustained : he himself with characteristic modesty would doubtless have wished it so. But it would not be fitting to pass over entirely without reference the many ways in which he spontaneously went beyond the duties normally associated with the positions he held in his efforts to promote the welfare of the Department and the success of its work.

His ripe experience of affairs in general, his business acumen and straight dealing, and his human and sympathetic outlook, gained for him the full confidence alike of his colleagues on the Governing Body of the Department, the members of the staff and the numerous farmers, fruit growers and market gardeners, and representatives of the cider industry brought into touch with him through the work of the Department.

As treasurer he was responsible for the supervision and control of the expenditure of large sums of public money, and his sense of duty, coupled with his desire to facilitate in every possible way

the development of the work of the Department along lines of genuine utility for all classes whom it was designed to serve, made him an admirable custodian of the available funds. He insisted that expenditure should be restricted within the limits of the funds at disposal and that the Department should be kept free from the hampering influence of overhanging debt.

To members of all grades of the staff he was invariably ready and anxious to render any help he could give : his friendly and wise advice was always available to them in periods of difficulty or trouble and many have had reason for deep gratitude. By all of them who came into close contact with him he was held in affectionate regard and his passing has been to them a personal loss.

He was so clearly the right man for the official positions which he held that throughout his long association with the Department his re-election was a matter of form only ; so long as he was prepared to serve there could be no possible question of an alternative choice. Fortunate indeed in having had the inestimable benefit of his services throughout the whole course of its history,the Department in its heavy loss recognises and carries the duty and responsibility of seeing that its future shall be a fitting tribute to the labours of one so intimately concerned with its establishment on sure foundations.

B. T. P. Barker.
E. P. West.

INTRODUCTION.

By Professor B. T. P. Barker, M.A., Director.

Before proceeding to the usual record of the activities of the Department during the year under review, reference must be made to the irreparable loss sustained in the closing days of the year by the death of Mr. H. B. Napier, J.P., LL.D., the Chairman of the Finance and Business Sub-Committee and the Treasurer of the Department since its inception. An account of his connection with it and an appreciation of the services rendered by him appear elsewhere in this Report. Here, therefore, it need only be added that, so intimately had he been identified with every phase of its development and so wholeheartedly had he given of his time, thought, interest and energy on its behalf, his passing leaves a place which no other can fill. As a link with the past—when the original parent National Fruit and Cider Institute was struggling through the initial critical years common to all similar institutions in this country concerned with research and the land in the early part of this century before the existing system had established itself—his position in relation to the Department in its present relatively highly developed organisation was unique. There are few still surviving who can speak with close personal knowledge of the full extent of the debt due to him : none more than the present writer, who had the privilege of being intimately associated with him in an official capacity since the inception of the scheme twenty-nine years ago, can appreciate the measure of the Department's loss. The tribute paid to him by the University of Bristol in the conferring of the honorary degree of LL.D. in June last, was richly deserved and, coming as it did in the last year of his life, constituted a fitting and timely acknowledgment of his services to the Department and to agricultural progress in the West of England.

In addition to this heavy blow, the Department has suffered seriously during the year from the enforced absence since April of Messrs. Grove and Tutin, two of the senior members of the staff at Long Ashton, owing to prolonged illness. In the case of Mr. Grove, there is no prospect of his return before Easter, 1933, and the temporary arrangements made to carry on the investigations on cider, under which Mr. Charley became responsible for the

laboratory side of the experimental work and Mr. Pickford for the practical section in the cider house, will remain in force until the completion of the active part of the current cider year. This arrangement has necessarily affected to some extent the work under the Scheme for Local Instruction in Cider Making for which Mr. Pickford acts as Instructor : thanks, however, to the cordial co-operation of the members concerned on the staffs of the Agricultural Education Departments of the counties participating in the scheme, it has been possible to avoid serious interferences. In the case of Mr. Tutin, a rapid recovery in the closing weeks of the year has enabled him to restart his duties at the beginning of 1933. His absence during the whole of the growing season of the year considerably hampered the progress of the programme of the plant pathologists on the staff on account of his responsibility for the chemical side of the conjoint work on various problems of disease and pest control. To minimise as far as possible a similar difficulty in 1933, Mr.T.J.P. Pearce, B.Sc., was awarded a temporary post-graduate research studentship in October, 1932, for the pursuance of investigations on certain of the more pressing problems then at a standstill owing to Mr. Tutin's breakdown in health. Now that the latter has been able to resume, it is hoped that with the help of Mr. Pearce an enlarged programme can be undertaken during 1933.

To a lesser degree other sections of the work of the Department also suffered through the absence of various members of the staff for shorter periods on account of illness. Hitherto, the Department had escaped exceptionally lightly in this respect, but 1932 will certainly stand out conspicuously as a year of almost continuous misfortune as regards sickness. It was marred, too, at the end by an accident in the cider house in which the cider foreman, Mr. Hathway, was involved : he must be accounted fortunate in having escaped more serious injury.

Notwithstanding the very serious difficulties under which the Department laboured throughout the year, encouraging progress can be recorded in several important directions. The Berkeley Square Agricultural Advisory Centre and the Campden Canning Research Station largely escaped the run of illness which beset the staff of the Long Ashton Research Station and can show notable developments during the year under review. The activities of the former are referred to in detail in the article on Advisory Work in the following pages : the outstanding feature has been the extension of the Veterinary section to include the diseases of poultry. A separate poultry pathological laboratory has been equipped and the services of the pathologist in charge, Mr. J. S. Garside, have been in great request since its establishment.

The Campden Station has continued to fulfil its important function as the advisory and research centre of the rapidly expanding fruit and vegetable canning industry in this country. The gratifying measure of financial support received from the commercial firms associated with the industry is sure evidence of their estimate of the value of its work, which continues to show striking growth each year. Under its new constitution, a separate annual report is issued for circulation to the subscribers and to that reference should be made for detailed particulars of its activities. A change in the control of the Station has been made during the year, in view of the near approach of the time when the industry itself will have to undertake the full responsibility of its administration : a separate Campden Sub-Committee of the Agricultural Committee of the University has been appointed and on this the subscribing firms of the industry now have equal representation with the nominees of the University.

As far as the disturbance of staff illness permitted, the Long Ashton Station has maintained steadily the major lines of investigation with which it is specially identified. The close contacts established during recent years with the commercial fruit growers of the country, as well as those associated with the cider industry and the various interests concerned with willow growing and utilisation, have continued to be developed, and these have proved of the greatest service in keeping the researches in line with the practical needs of the period.

On the financial side the Department has passed through a year of anxiety. The Government grant to the Campden Station remained at the normal amount owing to the agreement made with the canning industry in respect of the financial support required from the latter, but the grants in respect of the research and advisory work of Long Ashton and Berkeley Square were subjected to cuts corresponding to those made in the cases of similar research institutes and advisory centres elsewhere. Further, the Long Ashton Station sustained a large loss in income on account of the expiration of the five year grant received from the Empire Marketing Board for the investigation on fruit quality : this terminated at the end of July, 1932. In recognition of the importance of this line of work and the results accruing therefrom of value to fruit growers throughout the Empire, a supplementary grant to permit of the continuance of the work on a reduced scale was made for a further period expiring at the end of March, 1933. An endeavour to obtain a renewal for another term of years is being made : a complete stoppage of these investigations at this stage would mean the abandonment of one of the most promising and productive

lines of enquiry in the realm of fruit research. The reduction of the annual grants received from two of the contributing County Councils and the suspension—temporarily, it is hoped—of the contribution of the Dorset County Council in aid of the Scheme for Local Instruction in Cider Making, also added to the financial difficulties. Various economies have had to be effected to prevent over-expenditure, but it has been possible to avoid any severe curtailment of any branch of the work.

Staff.—The Department has had few changes in staff personnel during the year and those have been confined to junior appointments.

At Long Ashton an interchange of appointments was made between the two entomologists on the staff, Dr. C. L. Walton, the Research Entomologist, having taken over the duties of Advisory Officer in this subject from Dr. H. G. H. Kearns, who in future will give his primary attention to the entomological research associated with fruit culture. This change has been pending since Mr. Staniland, the previous Advisory Officer, left the Station early in 1931, but owing to the illness of Dr. Walton at that time and the subsequent delay in securing Treasury sanction to the rearrangement, it has only been possible to put it into effect recently. By the interchange the Advisory Service will gain the advantage of Dr. Walton's long experience and knowledge of advisory work on the pests of agricultural crops in general, while Dr. Kearns will be able to devote himself more exclusively to the researches on horticultural insect pests in which he has been specially interested for some time.

Miss L. D. M. Knight retired from her appointment of Research Assistant in Chemistry on her marriage in July. Her place has been taken by Mr. F. C. Lewis, whose post under the Empire Marketing Board Scheme of research on fruit quality lapsed on the reduction of the Board's grant referred to above.

Mr. C. T. Williams has vacated his position on the Assistant Recording staff and has been succeeded by Mr. C. F. Perry.

The temporary post-graduate studentship for research on the chemistry and physics of spray fluids, established in consequence of the illness of Mr. Tutin, has been awarded to Mr. T. J. P. Pearce, B.Sc., who under Professor Garner's direction had previously been investigating physico-chemical problems in the Chemical Department at Bristol University. He will continue to have the benefit of Professor Garner's supervision and advice in his present work, the latter having kindly agreed to undertake this in consequence of Mr. Tutin's absence.

During the course of the year several post-graduates and other students have participated in the work of the Station.

Professor E. L. Proebsting completed his year of study leave, spent mainly at Long Ashton on investigations on " the potassium status of soils in relation to the problem of potassium deficiency of fruit trees," and has now returned to the University of California, U.S.A., of which he is a member of the staff of the Department of Pomology.

Miss M. M. Walker, a graduate of Girton College, Cambridge, returned to spend a short period, completing an investigation on Willow Canker upon which she had been engaged at the Cambridge University Botanical Laboratory after she left Long Ashton in 1931.

Mr. D. V. Karmarkar, M.Sc., has continued throughout the year his researches on certain features of the nitrogen metabolism of apple trees, which he is pursuing as a candidate for the degree of Ph.D. at Bristol University.

Miss M. Brewer, B.Sc., a candidate for the degree of M.Sc. at Bristol University, has begun an investigation on Willow Galls.

Dr. J. Bloom continued his investigations on the toxic substances of Pyrethrum flowers begun in 1931, this work being aided by a grant from the Colston Research Society.

Miss K. Beard and Miss M. Carlton, honours students of Bristol University, have assisted Drs. Kearns and Walton in their investigations on the control of the raspberry and loganberry beetle and on the anatomy of Carabid beetles.

Messrs. Harold C. Mellor and H. Sealey, from the Imperial College of Science, participated in the recording work associated with some of the pomological investigations in progress in the fruit plantations during the course of the Long Vacation in the summer.

Mr. H. M. Hutchinson, of Bristol University, rendered very useful assistance to Mr. L. Ogilvie, the Advisory Mycologist of the Station, in his research on the Rust Disease of Basket Willows.

Towards the end of November Mr. C. T. Williams, M.A., a member of the technical staff of Messrs. Guinness, Dublin, came for a period of study of the science and practice of cider making and has assisted Messrs. Charley and Pickford in carrying out the season's programme of experimental work on cider.

At the Berkeley Square Advisory Centre, Mr. R. B. H. Round, B.Sc., has resigned his post as Assistant Advisory Chemist and has been succeeded by Mr. H. T. Watkins, M.Sc., who has been previously on the staff of the Agricultural Department of the University of Wales at University College, Aberystwyth.

Mr. J. S. Garside, M.R.C.V.S., D.V.S.M., a former student under Prof. Maitland at Manchester University, has been appointed Poultry Pathologist to take charge of the work of the newly-established Poultry Pathological Laboratory. The character of his duties brings him into close association with Mr. Menzies, the Veterinary Adviser for the Bristol Province ; it is anticipated that, as a consequence of this new appointment, it will be possible to give the problems of animal diseases in the Province extended attention in future.

A special grant has been made by the Agricultural Research Council to meet the cost of chemical investigations on the composition of herbage samples necessitated in the course of the grassland investigations of the Department. Mr. L. G. G. Warne, B.Sc., from the Botanical Department of Bristol University, has been appointed to carry out the required analytical work.

Buildings and Land.—Financial considerations throughout the year have rendered out of the question any developments at Long Ashton in the direction of new buildings, costly equipment, or plantation extensions. The new wing of the laboratory building, which was in course of erection during 1931, was completed at the beginning of 1932 and was brought into full use immediately. The additional accommodation thus available has proved invaluable already in enabling the general laboratory work to be carried on under much improved conditions and in providing room for workers who otherwise could not have been received.

With the exception of about 2 acres of the hillside land, which have been planted with standard trees of cider varieties of apples and represent the beginning of a much larger grass orchard intended to be established gradually by annual plantings on a similar scale, there has been no extension in the area under fruit. Some of the old plots having served their experimental purposes have been grubbed and the land thus coming vacant has been replanted with soft fruit for new experiments and with new seedling varieties of various fruits bred at the Station for trial purposes. In the latter connection, the distribution of material of new seedlings of the Station which have shown promise after trial is now in operation and particulars of the distribution scheme will be found in one of the articles included in this Report.

In addition to the usual distribution of a limited number of standard trees of cider varieties of apples for trial orchard purposes in approved locations throughout the contributing counties, apple trees worked on Mr. Spinks' series of selected "free" rootstocks are being sent out each season for planting on various growers'

farms to extend under varied conditions the trials of these root-stocks. At this point also, reference can be made to the numerous constantly increasing series of experiments on manuring and nutrition, ringing, spraying and other aspects of pomology in progress in the fruit growing areas throughout the whole country undertaken in conjunction with local growers. The warmest thanks of the Station are due to the latter for the facilities which they have provided, for their assistance in the work entailed by the experiments, and for their interest and cordial co-operation.

The chief features among the events of the year at the Station, apart from the Annual Tasting Day, have been the visits of the Horticultural Education Association and the Wisbech and District Fruit Growers' Association. The Annual Summer Conference of the former Association was held at Bristol, with the University Men's Hostel, Wills' Hall, as its headquarters. On both of the days of the Conference the Association spent part of the time at the Station, where arrangements were made for as much as possible of the work in season to be seen. The attendance was well representative of the research, advisory and educational sides of horticulture in this country, and many of the members had the opportunity of visiting Long Ashton for the first time, the personnel of the Association having changed considerably since its last visit ten years previously.

The Wisbech and District Fruit Growers' Association decided to hold their annual field day at the Station on June 8th, 1932, and made the long journey to Bristol by special train. The party numbered about 125 and was able to spend several hours in a general survey of the work in progress at the Station. It was a very successful visit and particularly welcome as a means of bringing the staff into closer touch with growers of one of the most remote, but most important fruit growing areas in the country.

The Annual Tasting Day was held as usual on the standing day, the first Thursday in May—May 5th. The Ministry of Agriculture and Fisheries was represented by Sir Charles G. Howell Thomas, the Permanent Secretary, Mr. H. V. Taylor, Horticultural Commissioner, and other officials. The former distributed the prizes to the successful competitors in the Annual Cider Competitions and also gave an address to the gathering. For the first time for several years the attendance did not create a new record, although the numbers were larger than anticipated under the prevailing difficult conditions for those associated with the land. The same reason probably affected the number and size of the parties visiting the Station during the year, in spite of the fact that the number

was about normal for recent years. The complete list was as follows :—

Wiltshire Teachers' Refresher Course.
Christr. Thomas Bros. Ltd., Bristol.
Association of Teachers of Domestic Science.
Montpelier Men's Adult School, Bristol.
Soroptimist Club of Bristol.
Bedminster Co-operative Men's Guild, Bristol.
Wisbech and District Fruit Growers' Association.
Bristol University Chemical Society.
Wayfarers' Club, Bristol.
Cardiff Allotment Holders' Association.
Studley Horticultural College.
University of Bristol Tutorial Class.
Somerset and Dorset Branch of the Land Agents' Society.
Peasedown St. John Horticultural Association, Bath.
Totterdown and Knowle Co-operative Men's Guild, Bristol.
Redfield Brotherhood, Bristol.
Horticultural Education Association.
Fishponds Diocesan Training College, Bristol.
Cotham Secondary School Science Club, Bristol.

Undoubtedly also individual visitors would have been more numerous, especially those from far afield, but for the same reason. Even so, their number was again very large and a considerable call on the time of the staff was required, many having come for consultations and advice on problems of their own.

For reasons of economy, the normal programme of the Department in respect of educational exhibits at agricultural and horticultural shows was reduced, the number of shows attended being fewer and the exhibits themselves being usually on a less elaborate scale. The following is a list of shows to which exhibits were sent :—

Devon County Show, Tavistock.
Bath and West Show, Yeovil.
Three Counties Show, Gloucester.
Cheltenham Spa Floral Fête, Cheltenham.
Gillingham and Shaftesbury Show, Gillingham.
Abergavenny Horse Show, Abergavenny.
Imperial Fruit Show, Birmingham.
Brewers' Exhibition, London.

As usual, close contact with related research work at other institutions in this country has been maintained and in several instances investigations in collaboration with workers at some of these have been in progress. In other cases, to avoid unnecessary overlapping, arrangements have been made whereby, when research on the same problems is in course both at Long Ashton and elsewhere, investigations on certain aspects of the problems are being undertaken by the Long Ashton staff and other aspects by workers at the other institutions concerned.

In conclusion, the directors and members of the advisory and research staffs have received invaluable help from the administrative officials and the clerical and assistant staffs, and this opportunity of acknowledging their full and ready support throughout so difficult a year is especially welcomed.

PROGRESS REPORT ON FRUIT BREEDING.

By G. T. Spinks.

Two years have elapsed since the issue of the last report on Fruit Breeding at Long Ashton. During this period a few new families of seedlings of various fruits have been obtained, but the work has consisted mainly in the observation of the older seedlings and the selection and propagation of the best of these.

Distribution of New Varieties.—By the end of 1931 several new varieties which had been under trial for a number of years on a small scale were judged to be good enough to warrant their introduction to the public, and a Seedling Distribution Scheme was therefore inaugurated. Under this scheme certain classes of subscribers to the National Fruit and Cider Institute are entitled to receive material for propagating the new varieties which are available for distribution. Though the Institute does not guarantee the performance of any variety distributed, or imply any standard of merit by the offer of distribution, yet it is thought that all the varieties offered may be useful additions to the sorts now commonly grown. In some cases the fruits appear to fill gaps which at present exist in the season, while in others they are thought to be improvements in some respects on commercial varieties of the same season.

A year ago a few subscribers were enrolled under this scheme and received material of some of the new varieties. At the end of 1932, largely as the result of a small exhibit staged at the Imperial Fruit Show, a number of new subscribers, including nurserymen and commercial fruit-growers, have applied for material. The new varieties will thus receive a more extensive trial than it has been possible to give them at Long Ashton, and it is hoped that favourable reports of them will be received during the next few years. The new sorts which have been distributed include several apples and plums, one pear, two black currants and one blackberry. All these have now been named and brief particulars of them are given under the headings of the various fruits below. Other promising new varieties are still under trial and it is hoped that some of them will prove worthy of distribution in the near future.

Apples.—The following new varieties are available :—

PLYMOUTH CROSS. An early September dessert apple of good flavour, but possibly rather too acid for the popular taste. (Allington Pippin × Star of Devon : 1916.)

NEWPORT CROSS. Dessert, mid-September ; rather flat, almost covered deep crimson. (Devonshire Quarrenden × Cox's Orange Pippin : 1920.)

HEREFORD CROSS. Dessert, mid- to late September ; very similar to the previous variety but later in season. (Cox's Orange Pippin open-pollinated [?] : 1913.)

TAUNTON CROSS. Dessert, September to early October ; resembles Wealthy but has better flavour ; consistently good cropper and resistant to scab. (Wealthy open-pollinated : 1919.)

WORCESTER CROSS. Dessert, early October ; crimson flush and stripes ; good flavour. (Cox's Orange Pippin × Wealthy : 1920.)

GLOUCESTER CROSS. Dessert, October to November ; dull crimson flush and stripes ; good flavour of Cox type. (Cox's Orange Pippin open-pollinated : 1913.)

During the last two years crops on the seedling apples have been poor, but fruit has been obtained from about 250 trees. Most of these belong to families which have produced very few fruits of any value and 180 trees have been discarded. Only one seedling was thought to be definitely worth propagating for further trial, though several more may possibly be selected after further observation.

Pollinations have again been confined to crosses between seedling varieties and were aimed at the combination of (1) earliness, colour and flavour, (2) lateness, colour and flavour. No large programme of seed production has been arranged owing to the restricted area in the plantations available for the planting of fresh seedlings.

Pears.—The following new variety is being distributed :—

BRISTOL CROSS. A dessert pear in season in mid-October. Appearance and flavour good ; tree vigorous and of nice open habit ; consistently good cropper and resistant to scab. (Williams' Bon Chrétien × Conference : 1920.)

The crops on pear seedlings have also been poor, but about 50 trees have borne fruit. Of these, 20 have been discarded and none have been added to the list of those worthy of propagation, though several are still under consideration.

The pollinations performed have had as their object the production of early varieties of good size and quality. Selected seedling varieties have been used as parents in making crosses.

Plums.—New varieties available for distribution are as follows :—

TEME CROSS. Dessert, late August ; red on yellow ground ; very juicy and sweet, with good gage flavour. (Heron open-pollinated : 1919.)

AVON CROSS. Dessert, late September ; fairly large, oval ; red on yellow ground ; very juicy and sweet, with good gage flavour ; self-fertile. (Jefferson × Victoria : 1920.)

Severn Cross. Dessert, late September; large oval, golden; juicy, sweet; self-fertile. (Coe's Golden Drop × Giant Prune [?]: 1921.)

Wye Cross. Culinary, late September to early October; medium size, roundish; dark purple blue; hangs late on the tree; self-fertile. (Merryweather Damson × Cox's Emperor: 1916.)

Fruit has been obtained from about 60 seedling trees, though crops were very poor in 1932. Almost all these trees will be observed for another year or two but no fresh varieties have been propagated.

Seed has again been obtained by the self-pollination of selected seedling varieties, but very few seedlings were obtained from the seed of 1931, the majority of which failed to germinate.

Black Currants.—The following new varieties are being distributed:—

Mendip Cross. Same season as Boskoop, but has yielded double the crop at Long Ashton; fruit large and bright, on moderately long trusses; bushes vigorous and slightly spreading; fairly resistant to leaf-spot. (Baldwin × Boskoop: 1921.)

Cotswold Cross. Same season as Baldwin, but has yielded 20% heavier crops. Fruit moderately large, on compact trusses. Bushes vigorous and fairly upright. (Baldwin × Victoria: 1920.)

The trial plot of selected seedling varieties has now cropped for three years. The plot contains 44 seedling varieties, also Boskoop and two strains of Baldwin, in units of 24 bushes, the units usually being triplicated on different parts of the plot. Crop weights and various qualitative characters have been recorded for three years and it is now possible to form some judgment of the relative values of the varieties.

Seven seedling varieties have produced total crop weights which are higher than those of either of the strains of Baldwin, several others have produced approximately equal crops, while almost all the seedlings have exceeded Boskoop in crop weights.

Up to the present the variety described above under the name Cotswold Cross appears to be the best of the later varieties. It has actually borne the heaviest crops and is satisfactory as regards size of fruit, habit of bush, etc., while some other heavy croppers may possibly be eliminated owing to smallness of the fruit or drooping habit of the bush. The variety Mendip Cross has not borne quite such heavy crops, but it is as early as Boskoop and has given double the crop of that variety. One variety which is not being distributed at present may be of value as, although it has borne only about the same crop as Boskoop, it is three days earlier than that variety.

Several other seedling varieties may, after further trial, prove suitable for distribution, but it now seems evident that about 25 varieties have no particular value and can be discarded.

Three years ago several good selected seedlings were selfed and crossed, mainly with the idea of obtaining early varieties. Some 1,800 seedlings, representing five families, were obtained and will bear their first crop in 1933.

Raspberries.—One seedling variety which has been included in a trial of commercial varieties for the last three years has compared favourably with some of the best of those varieties. It is a very heavy cropper, a good dessert fruit and suitable for canning. This variety may be distributed before long but has not yet been offered under the scheme.

Reference was made in the Report two years ago to an early heavy-cropping but small-fruited seedling which had been used as a parent in making further crosses. Two families of seedlings were obtained by crossing this with Lloyd George and Improved Beehive respectively: at the same time a third family was raised from a cross between Lloyd George and Improved Beehive. These three families have now cropped for two years and have borne some very good fruit. In 1931 some 35 individuals were selected for propagation and another 21 were selected in 1932. Several years must elapse before sufficiently large clones can be worked up from each individual to establish proper trials.

About 400 young seedlings have been obtained from a cross between Viking and Preussen, but these will not fruit for another two years.

Blackberries.—One variety of blackberry is now being distributed:—

> Ashton Cross. Similar to wild blackberry; fruit large, bright; good flavour; good canner; very vigorous, heavy cropper, ripe from mid-August onwards. (Wild blackberry open-pollinated: 1920.)

The above blackberry has been selected as the best of the four varieties which have been under trial for several years. Crop-weight records over three years show that it is the heaviest cropper and it has given 50% heavier crops than the Himalaya berry grown on the same plot. This variety is one of the least susceptible of the seedling varieties to damage by very severe frost. The fruit has a considerably better flavour than the Himalaya berry.

Strawberries.—Progress in the breeding of strawberries has been disappointing. In the years 1929 to 1931 plants were selected from families which had been obtained from crosses in which such varieties as Tardive de Leopold and Madame Lefebvre had been used as parents. It had been hoped to obtain from these families some new varieties which would be vigorous and resistant to

diseases and pests. Many of the selected plants appeared to possess those qualities, but the clones raised from them have usually grown very unsatisfactorily. It appears that the ground on which they were growing was unsuitable for strawberries, as other varieties on the same plot were also failures. However, some of the seedling varieties were clearly not as good as it had been thought and they have been discarded. Good runners were obtained in 1932 from the remaining varieties and have been planted on a much better piece of ground, where it is hoped they will receive a satisfactory test.

Some of the seedlings obtained by crossing a vigorous unknown variety with Royal Sovereign and Stirling Castle respectively have fruited in 1932 and two seedlings have been propagated.

This year seed has been obtained by crossing the same unknown variety with Paxton and seedlings will be raised and fruited in due course.

NOTE ON THE NOMENCLATURE OF NEW VARIETIES RAISED AT LONG ASHTON.

In naming the new varieties of fruit raised at Long Ashton an attempt is being made to use a uniform system of nomenclature which will indicate that all the varieties have originated at the Institute.

In the first place each variety will be distinguished by a place-name, usually derived from the West Midlands or South West of England. Secondly the place-name will be followed by the word "Cross," which will indicate that the varieties are the result of crossing or hybridisation. The resulting compound names, such as Bristol Cross, Avon Cross and Mendip Cross, will thus have a local character and should be easily remembered. Names in which the correct spelling or pronunciation may cause difficulties will be avoided.

For the present it is proposed to use the names of towns for apples and pears, rivers for plums and hills for the bush-fruits.

SOME OBSERVATIONS UPON THE PARTIAL SELF STERILITY OF THE OBERSCHLESIEN STRAWBERRY AND ITS FAILURE TO POLLINATE TARDIVE DE LEOPOLD.

By Thomas Swarbrick and C. R. Thompson.

Introduction.

During the past few years extensive plantings of the two varieties of strawberry, Tardive de Leopold and Oberschlesien, have been made. Both have been introduced into this country from the Continent of Europe and have commended themselves to English growers mostly by reason of their vigorous growth and resistance to disease and particularly to the strawberry aphis.

The variety Tardive is known to be completely self sterile, possessing only abortive stamens, and consequently it must be planted alongside other varieties which will act as pollinators. Clearly, these latter varieties must fulfil certain conditions, viz. flower at the same time as the Tardive plants, and be capable of ensuring a complete "set" of fruits.

Several varieties have been recommended for this purpose at various times, but unfortunately these did not always meet with growers' approval as regards cropping capacity, vigour, or disease resistance. Furthermore, because the variety Oberschlesien was introduced about the same time as Tardive, it was often planted along with it as a pollinator. It happens, therefore, that at the present time there are a considerable number of plantations which consist entirely of the two varieties Tardive and Oberschlesien.

It is not proposed at this point to discuss the relative merits of these two varieites, but to record and discuss certain observations made on commercial holdings in the Midlands and West of England concerning their cropping performance when they are interplanted, and to give the results of some pollination experiments, carried out in the greenhouses at the Long Ashton Research Station in the spring of 1933.*

Editorial Note. The inclusion of the latter in this Annual Report for 1932 has been arranged so that growers may have the information before the next planting season begins.

Field Observations.

In the summer of 1930 it was reported by a large grower of strawberries in the Midlands that for the second time in succession he had failed to obtain a satisfactory crop of Tardive from a large field on his farm. This failure represented a very serious loss of revenue and caused great concern. Upon investigation it was found that Oberschlesien had been used for interplanting with a view to pollination. It was also ascertained that within a comparatively short distance almost equally large fields of Tardive were cropping very heavily indeed. A preliminary inquiry among the strawberry growers of the area showed that while some of them were obtaining highly satisfactory crops from Tardive and were extending their plantings of this variety, others were decidedly unsuccessful and were scrapping their beds of Tardive. Such a situation obviously merited rather detailed examination in order to discover the factors which were leading to success in the one case and failure in the other.

Growers' plantations were visited and, wherever possible, careful examinations of the strawberry fields were made and detailed histories and cropping records collected. As the result of this survey—carried out during the summer of 1931 and 1932—several facts became unmistakably clear. These, in the probable order of their importance, are as follows :—

1. Plantations of Tardive with Royal Sovereign used as the pollinator variety were almost invariably successful, except in those cases where the pollinator variety consisted only of one or two rows of plants every ten or twelve yards. In these cases there was a strong suspicion that there was an insufficient quantity of pollinator plants, because the beds always cropped better where they adjoined the Sovereign plants. The best results were found in those cases where the pollinator variety was planted in good sized beds and constituted a fair proportion of the total plantation. This point appears to be of considerable economic importance.

2. Plantations of Tardive, with Oberschlesien used as the pollinator, were rarely, if ever, successful, except where either the Tardive or Oberschlesien stocks contained rogues of other varieties, notably Paxton or Royal Sovereign. In a number of cases the complete crop failure of *both* varieties in such a combination was found. It was abundantly clear that under field conditions Oberschlesien was not a satisfactory pollinator variety to plant with Tardive de Leopold.

3. Where large blocks of Oberschlesien plants were found far enough removed from all other varieties *except* Tardive, the crop was not satisfactory as regards amount and always contained an unduly large number of malformed and "hard tipped" berries. The prevalence of these "hard tipped" berries in a crop of Oberschlesien has often been reported, and is in fact urged against the variety particularly by the canning industry. On the other hand, where the Oberschlesien stock was mixed with such varieties as Paxton and Sovereign—which was in fact very often—or where it was growing alongside these varieties, the crop was not only satisfactory as regards amount but malformed or "hard tipped" berries were non-existent. It is difficult to escape the suggestion that the malformed berries are caused by a partial self sterility of the variety resulting from defective pollen, and that this might also account for its failure to pollinate Tardive.

These observations were at once made the basis of recommendations to growers for the proper interplanting of the Tardive variety. It was clear that the Oberschlesien could not be recommended, and in fact there was every reason to expect that this variety itself would be improved by being planted alongside a suitable variety to act as a pollinator. It was also suggested that the beds of both Tardive and the pollinator variety should not be more than ten yards wide and that it was not enough to plant single rows of a variety to serve for pollination purposes. Pollinating beds of not less than five yards wide were suggested. In this way a reasonable mass of bloom is available and the possibility of pollen distribution is increased.

Pollination Experiments under Controlled Greenhouse Conditions.

The field observations recorded in the previous section led naturally to the carrying out of definite pollination trials under controlled conditions. A preliminary experiment was therefore conducted in the greenhouse at Long Ashton in the spring of 1933, and the results are recorded here. A considerable number of maiden plants in pots of the varieties Royal Sovereign, Oberschlesien and Tardive de Leopold were available.

The plants of Royal Sovereign, Oberschlesien and Tardive de Leopold were each divided into three groups, which were used as follows :—

Royal Sovereign.

Group 1. These plants were used as a source of pollen for the *Oberschlesien* Group 1 plants.

Group 2. These plants were used as a source of pollen for the *Tardive* Group 1 plants.

Group 3. These plants were segregated into a distant part of the house to prevent cross-pollination.

Oberschlesien.

Group 1. These plants were pollinated with *Royal Sovereign* pollen.

Group 2. These plants were used as the source of pollen for use on the Group 2 plants of *Tardive de Leopold.* In the act of collecting pollen on the rabbit's tail the flowers were efficiently self-pollinated. This forms the difference between Groups 2 and 3.

Group 3. These plants were segregated into a distant part of the house to prevent any cross-pollination.

Tardive de Leopold.

Group 1. These plants were pollinated with *Royal Sovereign* pollen.

Group 2. These plants were pollinated with *Oberschlesien* pollen.

Group 3. These plants were segregated into a distant part of the greenhouse to prevent any cross-pollination.

All plants that were segregated were moved into distant parts of the greenhouse before blossoming.

For the purposes of pollination three rabbits' tails were used so that there was no contamination of the pollens, care being also taken to keep the rabbits' tails themselves from touching each other. The three tails were labelled and used in the following way : No. 1 for collecting pollen from Royal Sovereign Group 1 and using it on Oberschlesien Group 1 ; No. 2 for collecting pollen from Royal Sovereign Group 2 and using it on Tardive de Leopold Group 1 ; No. 3 for collecting pollen from Oberschlesien Group 2 and using it on Tardive de Leopold Group 2.

The transfer of pollen was always done at about noon each day during the commencement of the flowering season. Towards the latter end of the season, when there were fewer flowers, it was done every other day.

As an additional check upon the results of this pollination experiment, two germination tests were carried out upon the pollen of the two varieties Royal Sovereign and Oberschlesien. These tests were made in the laboratory by Mr. Maltby, and the authors gratefully acknowledge his assistance in this particular part of the investigation.

Results.

The results of the pollen germination tests will be dealt with at the end of this section. The results of the pollination trials are presented first and it will be seen that they are as conclusive as those of a preliminary experiment can well be.

Royal Sovereign.

Groups 1, 2 *and* 3. The case of Royal Sovereign may be dismissed at once by saying that this variety proved completely self fertile. It was observed, however, that the plants of Royal Sovereign which were used as a source of pollen for the Oberschlesien and Tardive plants, were more completely pollinated, and as a consequence had a better set of fruits (see Fig. 1, Plate I). It appears, therefore, that under greenhouse conditions, which largely preclude insect activity, the act of collecting pollen on a rabbit's tail has given a better pollination than where the plants were not disturbed in any way. Under field conditions a sufficient distribution of pollen appears to occur normally as the result of the wind and insect activity.

Oberschlesien.

Group 1. This group of plants received pollen from the variety Royal Sovereign, and it proved to be the only group of Oberschlesien which produced well shaped berries and gave mature fruit in any quantity. It can be seen from Fig. 2, Plate I, that the fertilization was all that could be wished for, since every blossom developed into a perfect fruit.

Group 2. The flowers of these plants served as the source of pollen for use on the Group 2 plants of Tardive, and in consequence were only pollinated with their own pollen, seeing that none could be collected on the rabbit's tail from the non-pollen-bearing Tardive. In spite of the variety being in this way very efficiently self-pollinated it can be seen from Fig. 3, Plate I, that the fruit is malformed and under-developed, thus demonstrating partial self sterility. From the economic point of view it can be treated as completely self sterile. since the majority of fruits produced are of very poor quality.

Group 3. This group of plants is in marked contrast to that of Group 1 of the same variety, where the plants were pollinated with Royal Sovereign. It is shown in Fig. 4, Plate I, that where no self pollinating was carried out, the " set " of fruits is even worse than that of Group 2. A very small proportion of the flowers " set " and the fruits which developed from them were invariably malformed and imperfect : in fact only one berry from the group of 18 plants was perfect.

For purpose of easy comparison see Fig. 1, Plate III, which combines in a left to right sequence Figs. 1, 2, 3 and 4 of Plate I.

Tardive de Leopold.

Group 1. This group should be compared with Group 1 of Oberschlesien which received similar treatment, viz. pollen from Royal Sovereign plants. As in the case of Oberschlesien, almost every flower—with the exception of those produced late—has developed into a perfectly shaped fruit. It must be borne in mind that Royal Sovereign had finished flowering several days earlier than Tardive, and in consequence the late blossoms of the latter variety could not be pollinated. The result of the pollination of this group is well illustrated in Figs. 5 and 6. Plate I, showing a maiden plant and a two-year-old plant respectively.

It should be mentioned here that during the spring of 1932 Royal Sovereign and Tardive plants were grown side by side in the glasshouse and no artificial pollination was done, with the result that only three or four fruits were gathered from the Tardives. This can easily be accounted for by the fact that there was no artificial transfer of pollen from one plant to the other.

Group 2. In this group where Oberschlesien pollen was used in pollination there was a very indifferent "set" of fruits indeed. Many of the blossoms failed to develop at all, and invariably those which "set" developed into very malformed fruits of no saleable value. A typical plant of this group is shown in Fig. 7, Plate II. Here on the one hand it is clearly shown that the pollen of Oberschlesien is incapable of establishing successful "set" of Tardive flowers, and on the other that the variety is partially self-sterile itself. It is most interesting and important to observe that, in spite of an efficient transfer of Oberschlesien pollen on to the Tardive flowers, the latter should have so obviously failed to develop into normal fruits. While from this transfer of Oberschlesien pollen a few fruits have developed, yet all are misshapen and it must be insisted that from an economic standpoint the failure is complete.

Group 3. This group of plants is similar to those of Group 3 of Oberschlesien, in that both were segregated into a distant part of the glasshouse to prevent any cross-pollination. It is shown that whereas a few very malformed fruits developed in the Oberschlesiens, none whatever have developed in this group of Tardive plants, which confirms beyond doubt that the variety is completely self-sterile. (See Figs. 8 and 9, Plate II, showing a maiden and a two-year-plant respectively.) The cluster of undeveloped flower trusses so

characteristic of blossoms which have failed to set are very well illustrated in Fig. 9, Plate II.

Figures 1 and 5, Plate I, and Fig. 8, Plate III, are collected into a group in Fig. 2, Plate III. This group clearly shows the heavy "set" of fruits induced by the use of Royal Sovereign pollen on the Oberschlesiens, and the partial self sterility of the latter variety.

Pollen Germination Tests.

With the above practical results in mind the pollen germination tests are of interest. It was found that under identical conditions, the pollen of Royal Sovereign began to germinate in 2½ hours. In 18 hours about 70 per cent. of the pollen of this variety had germinated and many of the pollen grains had produced long vigorous germ tubes. The pollen was obviously highly viable and strong. The Oberschlesien pollen, on the other hand, did not show any signs of germinating in less than 5 hours, and even after 18 hours not more than 25 per cent. of the pollen grains had germinated. Those which did germinate, produced very short weak germ tubes not more than twice or three times as long as the diameter of the original pollen grain. The contrast between the viability and the vigour of the pollen of the Oberschlesien and Royal Sovereign was most marked. In the case of Tardive de Leopold no pollen could be found.

General Considerations.

Great practical significance attaches to the observations recorded in this paper. Oberschlesien cannot be regarded as a suitable variety to plant with Tardive for the purposes of pollination, nor would it appear wise to plant large areas of the latter variety without making adequate provision for cross-pollination. In this connection variety mixture in the Oberschlesien is not the unmitigated evil that variety mixtures sometimes are. It is not suggested that the variety should be purposely mixed with rogues in order to ensure pollination, but growers are advised that the purer the stock the greater will be the need to provide facilities for cross-pollination. As would be expected, the common rogue with Tardive at the present time is Oberschlesien and *vice versa*, but it is evident that neither succeeds to pollinate the other successfully. Growers who find that their crop of Oberschlesien contains an unduly high proportion of malformed fruits should suspect lack of pollination, and where possible take steps to provide this essential requirement to this variety.

In the Midlands and in our experience Royal Sovereign has proved itself to be a satisfactory pollinator for both Tardive and

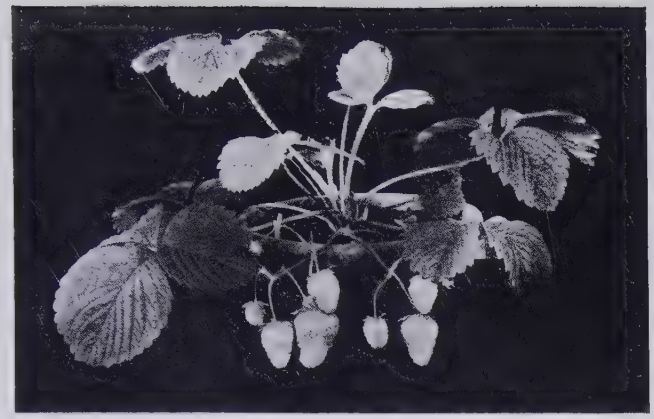

FIG. 1

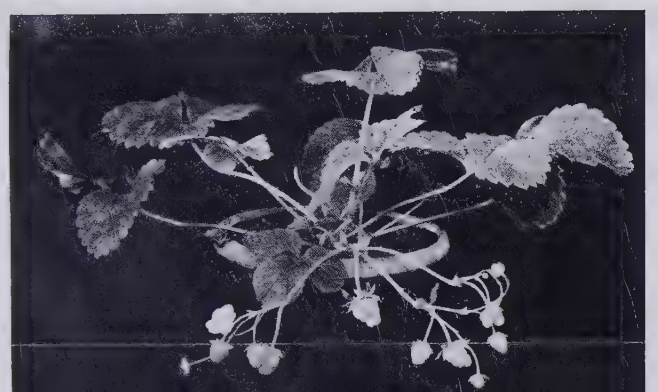

FIG. 3

FIG. 4

FIG. 5

FIG. 6

PLATE I.

FIG. 1.—Royal Sovereign, self pollinated.
FIG. 2.—Oberschlesien, pollinated with Royal Sovereign.
FIG. 3.—Oberschlesien, self pollinated.
FIG. 4.—Oberschlesien, "segregated."
FIG. 5.—Tardive, 1 year plant, pollinated with Royal Sovereign.
FIG. 6.—Ditto, 2 year plant.

FIG. 7

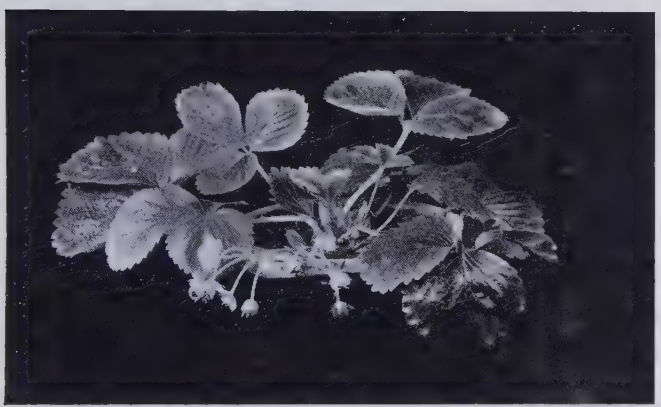

FIG. 8

FIG. 9

PLATE II.

FIG. 7.—Tardive, 2 year plant, pollinated with Oberschlesien.
FIG. 8.—Tardive, 1 year plant, "segregated."
FIG. 9.—Tardive, 2 year plant, ditto.

FIG. 1

FIG. 2

FIG. 3

PLATE III.

FIG. 1.—From left to right shows plants of Royal Sovereign self pollinated, Oberschlesien pollinated with Royal Sovereign, Oberschlesien self pollinated, and Oberschlesien "segregated."

FIG. 2.—From left to right shows plants of Royal Sovereign self pollinated, Tardive, 1 year plant, pollinated with Royal Sovereign, and Tardive, 1 year plant, "segregated."

FIG. 3.—From left to right shows plants of Royal Sovereign self pollinated, Tardive, 2 year plant, pollinated with Royal Sovereign, Tardive, 2 year plant, pollinated with Oberschlesien, and Tardive "segregated."

Oberschleien. Whether it is the best possible variety future experiment and observation alone can determine. It must be pointed out that, when it is used to pollinate Tardive, the last few picks of fruit are often malformed, due no doubt to the fact that the Royal Sovereign flowers are over before these flowers open. Under glasshouse conditions this could be corrected, as the Tardives could be forced slightly earlier than the Royal Sovereigns. Some growers use Paxton as a pollinator for Tardive with apparent success, but in the Midlands generally it is for several reasons difficult to establish and maintain a satisfactory bed of this variety. Growers who are successful with Oberschelsien and Tardive should exercise caution when planting new areas in order to make sure that the conditions of their previous success are provided for in the new plantings.

As opportunity provides itself observations upon the most suitable variety to plant with Tardive will be continued. As far as possible the observations will be confined to varieties which commend themselves to growers as embodying the desirable features of high cropping capacity, good fruit quality and reasonable resistance to diseases. Both Oberschlesien and Tardive are undoubtedly good varieties, but in many instances they have come into ill repute with the canning industry because such variable samples have been received. It is suggested that with proper facilities for cross-pollination there is no reason why these varieties should not rank with others for canning purposes.

It was mentioned earlier that the beds of the pollinator variety must be large enough to present a reasonable mass of blossoms. Observations made in the field suggest that the three varieties Royal Sovereign, Oberschlesien and Tardive make a desirable combination, since they cover a very wide range of the strawberry season. The one variety serves as a pollinator for the other two. The beds of Oberschlesien and Tardive preferably should not be more than 10 yards wide and they should adjoin beds of Royal Sovereign not less than five yards wide.

A CONTRIBUTION TO THE KNOWLEDGE OF THE CHEMISTRY OF RASPBERRY VARIETIES WITH SPECIAL REFERENCE TO ITS BEARING ON CANNING QUALITY.

By Lucy D. M. Knight.

Introduction.

In attempting to develop a fruit canning industry in this country the importance of varietal qualities was early recognised, and as the result of trials at the Campden Research Station and of experience gathered over a few seasons in commercial canneries, certain varieties of each class of fruit have been selected as good canners. The selections, however, have been based on purely empirical canning tests, and it has been obvious that the order of merit as canners into which different varieties fall may be substantially changed according to the source of origin of the fruits and to seasonal influences. It is not possible from the results of such experiences or from the general literature on canning to form any clear conception of the nature of the problems which present themselves relative to canning quality, or of the possible relationships between canning properties and the factors relating to the growing of the fruits which influence these. It is merely known that varieties of the same fruit may differ widely in appearance, colour, flavour and texture, and that such factors influence the canners' choice of fruit.

The qualities which the canner requires of fruits for canning purposes may be seen from the method of awarding points in important competitions, such as those at the Imperial Fruit Show. In the schedule for this Show, 20 points are awarded for condition of fruit, which includes firmness, lack of seediness, etc.; 15 for flavour, where stress is placed on the retention of the characters of the fresh fruit; 15 for the colour of the fruit; and 5 for the condition of the syrup.

In the 1931 report of the Campden Research Station, where the majority of serious fruit canning variety trials carried out in this country have been made, a statement is made as follows: "As the quality of the canned article depends on the quality of the original fresh fruit, such questions as the effect of strain, age of

plants, manurial treatment, etc., are problems . . . for research." The writer in the report adds that the work which has been done so far has produced inconclusive results, and that the problems need extensive investigation. It is also the experience of the Campden workers that certain firm fruits such as apples, plums and gooseberries are not affected by these factors to such an extent as the soft fruits such as strawberries, blackberries, loganberries and raspberries, which are more perishable.

The canning qualities of the fruits utilised in this country have thus been determined until the present time only by empirical canning tests, and it can be safely asserted that knowledge within the industry regarding the various chemical properties of the fruits which determine canning excellence is practically negligible.

In judging a canned fruit, the purchaser is generally guided in the first place by appearance and, therefore, the colour of the product, the evenness of grade and soundness of fruit are very important. The fruit must be of good texture and not too soft. In taste, it must be neither too sweet nor too acid ; the flavour must be fresh and full, and an aromatic odour characteristic of the particular class of fruit is an asset ; the syrup must be clear and palatable.

These points, viz. colour, texture, sweetness or acidity, fresh full flavour, and clear syrup—are doubtless influenced by the chemical composition of the fruits, but little knowledge concerning the relationships of these qualities and chemical characters appears to exist.

In discussing the colour of fruits, Chandler (3) states : " A review of the literature concerning the chemical nature of colour pigments, though requiring much space, would contribute little if anything towards the solution of the problem . . . of the development of attractive colour in fruits." He also states that only changes in nitrogen content can produce a measurable difference in colour. In the fruits containing anthocyanins (*e.g.* raspberry) a high nitrogen content may reduce the available supply of the substances from which these pigments are formed. The red colour of fruits such as the apple is influenced by the accumulations of carbohydrates in the tissue, Magness (4), but there is no complete evidence to support this view in the case of the soft fruits.

The desired texture of canned fruits varies for each sort of fruit, *e.g.* in fruits such as the peach, the flesh must be soft and yet firm enough to keep its shape ; in seeded fruits, the berries must be firm without being " seedy." The firmness of tissue in the peach

has been shown by Nightingale, Addoms and Blake (6) to be negatively correlated with the nitrogen contents of the fruits. These writers have also shown that the softer fruits have a lower protopectin content than harder varieties suitable for canning. After canning, which necessitates a type of cooking, relationships such as these, however, may be altered, since cooking brings about drastic pectin changes. It has also been shown that when insoluble pectin changes into the soluble form in fresh fruits, such as the apple, they tend to lose their flavour and texture characters and often become mealy. It is also popularly believed that culinary types of fruits have a higher pectin content than dessert types.

The palatability of fruits has been studied by Shaw (7). He stresses the importance of the ratio of sugar content to acid in determining the palatability of the apple. He suggests that for good flavour a high sugar content should be associated with a high acid content. Chandler (3) considers that there is probably some correlation between the sugar acid ratio and the quality of the fruit. He is certain that the amounts of sugar and acid in the fruit are of some importance in determining quality, but he considers it unlikely that the ratio is so important that its influence can be discerned among the many other factors which influence fruit quality.

The flavour of apples is known to be influenced by the sugars present in the fruit. With succulent fruits in which the proportion of juice to tissue is high, it is possible that the sugars and acids might play an even more important part in determining the flavour. The aromatic odours of fruits are due mainly to the products of vital activities of the plants and, though they determine the characteristic flavour in many cases, yet little is known of their composition.

The quality of the fruits plays a large part in determining the condition of the syrups in which they are preserved, and factors which influence quality thus also affect the syrups. In particular, factors such as nitrogen content, acidity and pectin might be expected to exert important influences, since nitrogen is known to affect firmness, and the cloudiness which sometimes develops in the syrups may be due to pectinous bodies which are, in their turn, affected by the conditions of acidity. Corrosion of tins, which is also a factor in cloudiness, has been shown in certain cases (5) to be caused by the action of anthocyanins at certain pH values.

Whilst it appears certain that many canning qualities will be capable of explanation on a chemical basis, the problems involved are likely to prove extremely complex. They include those concerned with the fresh fruits themselves and the changes which

occur during the process of canning and subsequent storage under the particular conditions which obtain in the cans.

In the initial experiments detailed in the present paper, an examination was made of certain of the simpler chemical constituents which occur in raspberries, and which are known to be associated with quality differences in fruits, in an attempt to discover any possible relationships which might appear between these compounds and the canning qualities of several commercial varieties of raspberries.

The fruits examined were from varieties of commercial merit and pedigree stock. The material was especially suitable for an investigation of this type, as the plants utilised have been grown in critical variety trials and were comparable in practically every cultural respect. Some of the stools were older than others, and this constituted the only important cultural difference between the varieties.

In the canning trials carried out in the investigation, a sample of each of the varieties was canned at the appropriate stage of ripeness, and the products examined about six months later. In the chemical investigations the following constituents were estimated at the time of the canning operations: total nitrogen, acidity, total sugars, reducing sugars, sucrose and soluble pectin.

The results of the investigations have so far shown that no apparent correlations exist between the canning quality of the fruits and the chemical features which have been considered.

Experimental Data.

A list of the fruits used in these investigations is given in Table I. This also shows the ages of the stools from which the fruits were obtained, the dates on which the fruits were picked and sampled, the details of the type of fruit (*i.e.* whether culinary or dessert) and the plots on which the varieties were grown.

The sites of the two plots from which samples were taken are very similar, being practically level, whilst the soils are both derived from mainly sedentary material of Keuper Marl origin, being medium loams. The Trial Plot had been under arable conditions for several years and was in good heart, but the Kingscraft Plot had only recently been broken up from old meadow land and was rather poorly supplied with potash.

The weather over the whole season was exceptionally wet and the fruits were very much affected. In many cases they appeared very damp immediately after picking, and if left overnight, they

TABLE I.

Details of the Varieties Investigated in this Experiment.

Variety.	Age of Stool.	Date of Sampling.	Culinary or Dessert.	Plot.
Baumforth A	5 years	July 16th	Culinary	Raspberry Variety Trial Plot
Improved Beehive ..	5 ,,	,, 10th	Dessert	,,
Parson's Fillbasket ..	5 ,,	,, 22nd	Culinary	,,
Red Cross	5 ,,	,, 14th	Dessert	,,
Pyne's Royal	5 ,,	,, ,,	,,	,,
Maclaren's Prolific ..	5 ,,	,, ,,	Culinary	,,
Herbert	5 ,,	,, ,,	,,	,,
Black Antwerp ..	4 ,,	,, 22nd	Dessert	,,
Duke of Cornwall ..	3 ,,	,, 10th	,,	,,
Lloyd George	3 ,,	,, ,,	,,	,,
Viking	3 ,,	,, 22nd	,,	,,
Norfolk Giant ..	2 ,,	,, 18th	Culinary	,,
Brocket Hall	2 ,,	,, 14th	Dessert	,,
A.R.C. 18	2 ,,	,, 18th	? (Seedling)	,,
Brighton	3 ,,	,, 22nd	Culinary	Kingscraft
Preussen	2 ,,	,, ,,	Dessert	,,

frequently developed mould growths which were serious enough to prevent them from being marketable as first-class fruits the following morning. It was necessary, therefore, that sampling, canning and preparing the fruits for chemical analyses should be done entirely on one day. This adverse weather effect must also be borne in mind when the canning results are considered.

Methods used in the Canning Experiments.

Punnets containing approximately 10lbs. of each sample of fruit already plugged, were brought into the laboratory on the dates shown in Table I. Here the fruit was sorted, and all grub-infested material and berries showing beetle markings, etc., were rejected. The final sample was as uniform in size and colour as possible and was representative of the best grade picked of each variety. The fruit was then packed into clean, scalded cans to within one-eighth of an inch of the top. The cans were Williams No. 1½, containing 9—12 oz. and, since the fruit is highly coloured, the double lacquered type was used.

The fruit was well shaken down in the cans and covered with a boiling syrup, which was made by dissolving 6lbs. of sugar in one gallon of distilled water. This strength was a compromise between the commercial strength (10lbs. of sugar per gallon) which has been judged as too sweet, and the usual domestic strength (4lbs. of sugar per gallon) which is often not sufficient when the fruit is tart.

In order to prevent the entrance of air into the cans, which causes a deterioration of the fruit on keeping, six cans of fruit were filled at one time and sealed immediately before the temperature of the syrup could be appreciably lowered. The method of sealing was by means of the " double seaming " hand can-closing machine. After sealing, each batch of cans was placed in a large vessel of boiling water and allowed to boil for 15 minutes. After the sterilisation process, the cans were cooled quickly in running water, so that the fruit should not be overcooked. They were then wiped dry and stored for subsequent examination.

It was thought that any period over six months would be a sufficient length of time to allow of a correct judgment of the quality of the canned samples. The cans were opened for testing on March 7th, 1932, and the canning qualities of the fruits were assessed by three competent judges with experience of canning requirements. The writer was present and took notes of the results.

The qualities considered in judging the fruits were those recognised as important by canners and referred to in the introduction, viz. colour, flavour, condition of the fruit and condition of the syrup. Although a definite pointing system was not followed, the differences between the varieties was sufficiently marked in most cases to make it highly probable that the order in which the various samples were placed as the result of the tests would be very close to that which other expert judges would establish.

In judging colour, intensity was especially noted, since some varieties tend to become bleached more than others, or to lose their colour to the syrup. In flavour the retention of characters typical of high quality fresh fruits (*i.e.* a good blend of acidity and sweetness combined with the delicate raspberry flavour) was regarded as desirable. In condition, attractiveness of appearance, evenness of size and firmness of the berry or pulpiness and seediness were taken into consideration. In the syrups the degree of excellence was judged by clarity and colour.

Chemical Methods.

On the same dates that the samples of fruit were canned, corresponding samples weighing four pounds were brought into the laboratory. The berries had been plugged as they were picked, and on arrival at the laboratory they were examined and a report was made on the size, condition, ripeness of the fruits, and the presence or absence of beetle marking. The fruits were then sorted and all abnormally ripe or significantly beetle damaged specimens were rejected, and leaves and foreign matter, etc., removed from the sample.

To obtain as true a sample as possible for the chemical analyses, the following method was adopted for each sample. The berries were gently but firmly crushed with a glass pestle in a glazed dish. Only a few berries were treated at one time, and the resulting mass was well mixed with a large spoon. A fair sample of the pulped fruit was placed in a small beaker as quickly as possible before any settling out of the juice or fermentation could take place. From this material, portions for analysis were weighed by difference. For nitrogen determinations, approximately 40 grams were weighed accurately and placed in a Kjeldahl flask and treated immediately with 40 cc. concentrated sulphuric acid. For sugars, a portion of approximately 50 grams was weighed accurately in a beaker and transferred to a wide-necked bottle containing hot alcohol of such a strength that, after the addition of the fruit (the moisture content of which was taken into consideration), the resulting alcohol was approximately 85 per cent. A little calcium carbonate was then added and the alcohol brought to the boil. The bottle was finally corked with a waxed cork and set aside for analysis. A similar method was used for the preservation of material for the estimation of acid content, with the exception that 70 gms. of material were accurately weighed out and placed in the bottle, and no calcium carbonate was added to the alcohol. For each estimation of pectin, approximately 100 gms. of the pulp (weighed accurately) were washed with hot water into a large Erlenmeyer flask. The fruit was covered with boiling water, the flask plugged with cotton wood and sterilised immediately.

Total nitrogen was subsequently determined by the Kjeldahl-Gunning-Arnold method. (" Methods of Analysis," A.O.A.C. 1930, Chap. II, p. 21.) Acidity was estimated by titration of aliquots of the alcoholic extract, after removal of the alcohol by distillation at 40°—45° C. and taking up with water, with $\frac{N}{10}$ sodium hydroxide, using phenol phthalein as indicator. Reducing sugars and sucrose were also determined on aliquots of the alcoholic extracts, the solvent being removed as in the acidity determinations; lead acetate-potassium oxalate procedure was followed to clear the solutions, and 10 per cent. citric acid was employed as hydrolysing agent for sucrose; the final determinations were carried out by Lane and Eynon's method (J. Soc. Chem. Ind., Vol. 42, p. 32, 1923; Vol. 44, p. 150, 1925). Pectin was estimated by the calcium pectate method of Carré and Haynes (Biochem. J., Vol. 16, p. 60, 1922).

Results.

The results of the canning tests and of the chemical determinations are presented in summarised form in Tables II and III.

TABLE II.

Results of Canning Tests.

Variety and Order of Merit.	Dessert or Culinary.	Colour.	Flavour.	Condition of Fruit.	Condition of Syrup.
1. Red Cross	D.	Very good	Very good	Good	Good
2. Pyne's Royal	D.	Very good	Rather insipid	Good, but slightly soft	Good
3. Improved Beehive ..	D.	Good. Very slightly pale	A little sweet, but good	Very firm. Good but small	Good
4. Brocket Hall	D.	Berries badly bleached	Good	Very good	Good
5. Black Antwerp	D.	Good	Good	Good	Slightly cloudy
6. Viking	D.	Good	Good, but slightly artificial	Fairly good ; slightly soft	Good
7. Preussen	D.	Good. Berry a little washed out	Sligthly artificial, but quite good	A little "seedy" ; rather soft	Good
8. Lloyd George	D.	Poor ; brownish	Fairly good	Fairly soft	Good
9. Duke of Cornwall ..	D.	Not good ; pale	Good ; slightly metallic	Seeds very prominent. Good	Good
10. Norfolk Giant	C.	Berries slightly bleached	Fair	Good	Clear
11. Herbert	C.	Brownish	Fair	Very soft	Cloudy
12. Maclaren's Prolific ..	C.	Fair	Fair ; metallic	Good	Cloudy
13. Baumforth A.	C.	Good	Very tart	Very soft	Good
14. A.R.C. 18 (Seedling) ..	D.?	Fairly good, but can attacked	Sharp, but little flavour	Good	Cloudy
15. Brighton	C.	Very dark	Poor	Soft	Very dark and slightly cloudy
16. Parson's Fillbasket ..	C.	Berries brown	Fair	Small and "seedy"	Not very clear

TABLE III.

COMPLETE CHEMICAL DATA OF VARIETIES—ARRANGED IN ORDER OF CANNING MERIT.

Variety and Order of Canning Merit.	Dessert or Culinary.	As Percentages of Fresh Weight.							
		Total Nitrogen.	Titratable Acidity.	Reducing Sugars as Laevulose.	Sucrose.	Total Sugars as Invert.	Ratios Sucrose / Reducing Sugars.	Ratios Total Sugars / Total Nitrogen.	Soluble Pectin as Ca. pectate.
		*	*	*	*	*	*	*	*
1. Red Cross	D.	0.232 (5)	1.72 (10)	2.14 (13)	0.33 (14)	2.38 (15)	0.1542 (10)	10.26 (13)	0.51 (8)
2. Pyne's Royal	D.	0.215 (11)	1.54 (13)	3.46 (4)	0.50 (7)	3.88 (6)	0.1445 (13)	18.05 (7)	0.49 (10)
3. Improved Beehive ..	D.	0.225 (6)	1.84 (5)	2.56 (11)	0.46 (8)	3.01 (12)	0.1797 (8)	13.38 (12)	0.54 (6)
4. Brocket Hall	D.	0.195 (16)	1.78 (8)	2.85 (9)	0.42 (12)	3.19 (10)	0.1473 (11)	16.36 (9)	0.64 (1)
5. Black Antwerp	D.	0.224 (7)	1.82 (6)	2.77 (10)	0.37 (13)	3.07 (11)	0.1336 (14)	13.71 (11)	0.51 (8)
6. Viking	D.	0.207 (13)	1.86 (4)	3.10 (8)	0.75 (4)	3.81 (7)	0.2419 (4)	18.41 (5)	0.41 (13)
7. Preussen	D.	0.199 (15)	1.28 (16)	3.12 (7)	1.01 (2)	4.07 (4)	0.3237 (2)	20.45 (2)	0.31 (15)
8. Lloyd George	D.	0.222 (8)	1.81 (7)	2.35 (12)	0.95 (3)	3.27 (9)	0.4042 (1)	14.72 (10)	0.57 (4)
9. Duke of Cornwall	D.	0.269 (1)	2.00 (3)	2.09 (15)	0.46 (8)	2.51 (13)	0.2202 (5)	9.33 (14)	0.58 (3)
10. Norfolk Giant	C.	0.262 (2)	2.15 (2)	2.13 (14)	0.43 (11)	2.43 (14)	0.2018 (6)	9.27 (15)	0.61 (2)
11. Herbert	C.	0.213 (12)	1.72 (10)	3.46 (4)	0.64 (5)	4.03 (5)	0.1849 (7)	18.92 (4)	0.38 (14)
12. Maclaren's Prolific ..	C.	0.238 (3)	1.40 (14)	4.08 (2)	0.59 (6)	4.56 (2)	0.1446 (12)	19.16 (3)	0.45 (12)
13. Baumforth A.	C.	0.216 (10)	2.19 (1)	4.25 (1)	1.21 (1)	5.34 (1)	0.2847 (3)	24.72 (1)	0.48 (11)
14. A.R.C. 18 (Seedling) ..	D.?	0.218 (9)	1.78 (8)	1.44 (16)	0.15 (15)	1.57 (16)	0.1042 (16)	5.27 (16)	0.30 (16)
15. Brighton	C.	0.201 (14)	1.32 (15)	3.33 (6)	0.06 (16)	3.41 (8)	0.1786 (9)	16.96 (8)	0.52 (7)
16. Parson's Fillbasket ..	C.	0.236 (4)	1.72 (10)	3.95 (3)	0.44 (10)	4.33 (3)	0.1114 (15)	18.35 (6)	0.56 (5)

* The values in brackets in each column denote the descending orders for the respective constituents, etc.

In Table II the varieties are listed in order of canning merit as determined by the tests, and it will be noticed that they are also grouped together into three main groups, viz.: numbers 1—3; 4—9; 10—16. This has been done because it was felt that very decided differences existed between varieties of different groups, whereas the differences between the members of each group were only slight, and in some cases of doubtful significance. The table also shows whether the fresh fruits are regarded primarily as of dessert or culinary quality and various relevant observations of the judges relating to colour, flavour, condition of the fruit when the cans were opened and the condition of the syrup are included.

In Table III the varieties are again arranged in order of canning merit and dessert or culinary qualities are given in addition to the results for total nitrogen, acidity, reducing sugars, sucrose, total sugars, ratios $\frac{\text{sucrose}}{\text{reducing sugars}}$, $\frac{\text{total sugars}}{\text{total nitrogen}}$ and soluble pectin.

Discussion.

Canning Qualities.

On the results of the canning tests the varieties have been classified into three main groups, and an attempt made to arrange the varieties within the groups into a definite order.

It has already been pointed out that differences between groups were well marked, but those between members of groups were in some cases rather small and of doubtful significance. Table II thus serves to differentiate clearly between varieties giving good, medium and poor results.

Examination of the table reveals certain points of note. In the first place, all the varieties in groups 1 and 2 are of dessert quality and all the varieties in group 3 are of the culinary class. The possible exception to this statement is "A.R.C.18," which is a seedling variety whose qualities have not yet been finally established, although the variety has been provisionally placed in the dessert group. This division is probably to be expected since the canner requires a firm berry of high grade quality with full raspberry flavour, and these are the properties which characterize fresh fruits of the dessert category.

The order given in the table does not agree entirely with the more general conclusions obtained by workers at the Campden Research Station (2), who have made more exhaustive investigations, but it is to be expected that in isolated trials such as the present, exceptions to general findings will occur. The canning results herein recorded, however, may be taken as referring to the

particular fruits used in the present tests, and as suitable for the objects attempted in the present investigation.

With regard to the individual quality features in the table—colour, flavour, condition of fruit and condition of syrup—it will bo noted that certain varieties occupy relatively low positions because of serious defects in one or more of these, whilst other features may be of desirable quality.

In connection with such points, the following comments may be made :—

Colour : All the Group I samples were of good colour, but in Group II " Brocket Hall " was badly bleached, " Lloyd George " was of poor colour, and " Preussen " and " Duke of Cornwall " were pale. In all cases in Group III, with the exception of " Baumforth A," the colour was defective.

Flavour : Several distinct points emerged in the data. The varieties " Pyne's Royal " and " Improved Beehive " appeared to be a little subacid. The varieties " Viking " and " Preussen," both of overseas origin, yielded flavours described as artificial, *i.e.* the flavours are unusual for English varieties and resembled artificial raspberry essences. Such characters would detract from their values as canning fruits in this country. " Baumforth A " and " A.R.C.18 " suggested high acidities to the palate. The varieties " Duke of Cornwall " and " Maclaren's Prolific " were rendered defective because of metallic taints.

Condition of Fruits : Many of the samples examined appear to have been rather soft, and this may have been partly due to the nature of the season. Three varieties in Group III were in good condition ; in the varieties " Duke of Cornwall " and " Parson's Fillbasket " the seeds were prominent.

Condition of the Syrup : In Groups I and II the only variety not yielding a clear syrup was " Black Antwerp." In Group III all varieties with the exception of " Norfolk Giant " and " Baumforth A " produced syrups which were not clear.

Chemical Constituents in relation to Canning Results.

Examination of the data presented in Table III shows that no simple correlation appears to exist between the order of canning merit of the varieties and any of the chemical features considered. There are, however, points of interest in the data and certain of these call for comment.

Nitrogen: Canning order in relation to nitrogen content is seen to be very irregular. Since seven of the varieties are relatively young (2 and 3 years—see Table I) it might have been expected from experience with fruits such as the apple that these young fruits would contain relatively high nitrogen contents. Although two of these young varieties have the highest nitrogen contents, the other five are all in the lower half of the list, and thus it would appear that the varietal characters in the present instance are possibly exerting stronger influences on the nitrogen content than are the differences in age. The two varieties from Kingscraft appear as Nos. 14 and 15 in the list and it may be that this is due to soil conditions.

Acidity: The relationship between canning order and acid values is seen to be very inconsistent and there appears to be an entire lack of correlation. In the canning table, the varieties "Baumforth A" and "A.R.C.18" are stated to be of acid flavour, whilst "Pyne's Royal" and "Improved Beehive" are described as "rather insipid" and "a little too sweet" respectively. "Baumforth A" has a high acid content, but the acidity of "A.R.C.18" is only medium and in this latter variety, the markedly sharp flavour may be due to poor sugar content. The acidity of "Improved Beehive" in spite of its sweet flavour is relatively high, but "Pyne's Royal" is definitely low in acid content. It would thus appear that taste is not a reliable index of total acid content, and it is possible that the sugars present act as masking agents to the acidity as determined by taste. The two Kingscraft varieties are again together at the bottom of the list.

Total Sugars: Since canning merit was found to be associated with high dessert quality, some degree of positive correlation between sugar content and high canning quality might have been expected, but no such relationship exists. Indeed it is found that of the six culinary varieties used in the tests, three of these occupy the first three places for sugar content, and two others are among the first eight varieties. This situation is vastly different from that which exists in the case of apples where high dessert quality and high sugar content are closely associated. The position of "Baumforth A" is remarkable. This variety is notably acid in flavour, and occupies first place for acidity, total sugars, reducing sugars and sucrose. The low positions of "Red Cross"—highest in the canning

tests—and of " Improved Beehive "—stated to be sweet, yet with a fairly high acid content and rather low sugar content—require mention. It is also to be noticed that the positions of the Kingscraft varieties are here very widely separated.

On comparing the order for total sugars with those for reducing sugars and sucrose, the orders for the former two are seen to be very similar, but that for sucrose differs widely from them.

The very large range of sugar contents in the varieties is remarkable. The variation is from 5.34 per cent. to 1.57 per cent.

Reducing Sugars : As the order of these is very similar to that for total sugars little further comment is necessary. The range of reducing sugars is large, and varies from 4.25 per cent. to 1.44 per cent.

Sucrose : The canning order is again very different from the order of sucrose content. As was the case for nitrogen, the fruits from the young plants did not contain high sucrose. Five of the seven varieties occupy positions in the lower half of the list. The range of values is again large, three varieties containing notably high amounts—" Baumforth A," " Preussen " and " Lloyd George "—whilst the variety " Brighton " had a very low content. The low position of " Red Cross " is again notable. The two Kingscraft varieties, " Preussen " and " Brighton," are very widely separated here, and it is thus apparent that their notable positions for this constituent are not due to a specific " Kingscraft " effect.

Soluble Pectin : The canning order is very widely scattered when considered in relation to this constituent and the culinary varieties do not occupy any significant position which might suggest a relationship between culinary properties and soluble pectin content. The varieties which produced cloudiness of syrup also give values for soluble pectin and acidity which are widely dispersed.

Ratios Sucrose/Reducing Sugars and Total Sugars/Nitrogen : The values for these ratios might be expected to yield correlations with high qualities in fruits, but in the present case no significant relationships are apparent. Moreover, they show no point of note with regard to the different ages of the plants and thus again support the view that age effects were not important in the experiments

Other Constituents : In view of the general lack of correlation

between the canning quality of the varieties and the chemical features examined, it is of interest to discuss the possibility of relationships with other chemical constituents. Thus Nightingale, Addoms and Blake (6) found that a positive correlation existed between the protopectin content and the canning qualities of two varieties of peaches, high protopectin being related to firmness of flesh and suitability for canning. This question of protopectin content as a factor influencing the firmness of fruits might well be investigated in connection with fruits such as the raspberry.

Greater knowledge is also necessary of the chemical constituents of the characteristic aromatic flavours which each fruit possesses, since these are of importance in determining canning quality. Again, colour of the product has been considered a major factor in the grading of the fruits in these experiments, and since the bleaching of raspberry fruits has been shown by Morris and Bryan (5) to be due largely to the complex reactions of the anthocyanin pigments with the tin container, this group of constituents requires further investigation.

The above three points would thus seem to call for early study in any further investigation of the relationships between the chemical constituents of raspberries and canning quality.

Summary and Conclusions.

1. The composition of sixteen varieties of raspberries grown under comparable conditions were examined in respect of the following constituents: total nitrogen, titratable acidity, total sugars, reducing sugars, sucrose and soluble pectin; the ratios $\frac{\text{sucrose}}{\text{reducing sugars}}$ and $\frac{\text{total sugars}}{\text{total nitrogen}}$ were also determined.

2. Large variations in chemical composition were found in the varieties, but these did not provide any obvious basis for assessing canning qualities or of classifying into dessert and culinary groups.

3. Taste was found to be an unreliable index of both acidity and content of total sugars.

4. Cloudiness in the syrup of canned fruits was not correlated either with total acid content or the percentage of soluble pectin.

5. Good canning qualities were closely related to high dessert properties and poor canning qualities were associated with culinary properties.

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THE SPRAYING OF FARM ORCHARDS AS A MEANS OF INCREASING THE CIDER FRUIT CROP.

By Thomas Swarbrick.

Introduction.

The period since the war has witnessed a steadily increasing consumption of cider in this country. This enlarged sale has increased the demand for cider apples, and as a consequence the price obtained by the grower for his cider fruit has risen considerably Before the war the price obtained for mixed cider fruit was usually £2 per ton or less, whereas in recent years the price has ranged about £5 per ton for mixed samples of good cider varieties.

It is now generally recognised that the home production of cider apples in a year of average crops is inadequate to meet the present demand and that this deficit necessitates the importation of large quantities of cider fruit, mainly from France. The cider makers thus find themselves in the unfortunate position of relying extensively upon the importation of their raw material. In order to keep the industry going at its present level of production it has been found necessary to allow the import of cider apples duty free. The present remission of the duty can only be regarded as a temporary measure to allow time for the production from the home orchards to be increased. It is essential, therefore, that during the next few years a sustained and genuine attempt should be made to increase the home supplies so as to meet as far as possible the requirements of the industry. As a first step in the direction of stimulating the output from English orchards, a guaranteed price of not less than £4 per ton for cider apples for the next five years has been offered by the Cider Makers' Association. This arrangement should serve to demonstrate to farmers the financial possibilities of supplying the industry with home-grown fruit.

Two possible methods of increasing the supplies of fruit suggest themselves, namely the planting of new orchards and the renovation of existing ones.

The planting of new trees cannot have any *immediate* influence. In the normal course, trees worked upon strong rootstocks and planted as standard trees in grass orchards cannot be expected to come into substantial bearing under fifteen years from planting. It is obvious, therefore, that the planting of new orchards or the

mending of existing ones cannot be expected to relieve the present situation. In order to ensure adequate supplies for the future new plantings are absolutely essential, but to meet the requirements of the next decade or so, attention must be directed in particular to the orchards already potentially capable of bearing considerable crops.

Many in this latter category can be very materially and easily improved in general health and vigour—from which will follow increased cropping—by the introduction of certain cultural practices, and in many instances great improvement would follow within one or two seasons from the appropriate treatment. Improved health and cropping follow very quickly upon improved nutritional conditions and the control of pests and diseases. The application of certain manures, the efficient management of the sward and suitable pruning will secure a general and often marked improvement in vigour. Spraying treatments and the control of pests and diseases will effect a marked increase in cropping, and will also tend to improve general health and vigour.

The main purpose of the present paper is to consider the major problems relating to the spraying of cider apple orchards, particularly the economic aspects of such spraying treatments.

The spraying of fruit trees as a control measure against insect pests and fungus diseases is now an established practice on commercial fruit holdings, but has not been as yet widely adopted in the farm orchards of the West Country. The reasons for this are fairly obvious. The orchards are usually regarded as a side line to the general farming practice, whilst the trees are often very large and the fruit is disposed of for cider making where unblemished fruit is not a vital necessity. Moreover, spraying equipment capable of dealing adequately with farm orchards is costly, and the profitable returns from such an outlay are not always apparent.

One of the present objects is to discuss in a general way the question of whether it pays to spray cider apple orchards. Spraying in general, and winter spraying in particular, is a rather expensive procedure, and this point is usually given undue prominence when the question of spraying farm orchards is under consideration. Spraying costs, stated without reference to the financial advantages which follow, undoubtedly prevent many growers from embarking upon the practice.

Precise and complete spraying costs are difficult to determine since a large number of variable factors affect these costs—factors such as the amount of water carting involved ; age, size and variety of tree ; kind of equipment used ; and the purely personal factor

of management. The last is a most vital factor and is followed closely in importance by the kind of equipment used. These points are discussed in turn in a later section in so far as they bear upon the problem of spraying cider apple orchards.

Common Pests and Diseases of Importance in Farm Orchards and their Control.

It is not generally recognised by the producers of cider apples that any factor which reduces leaf surface thereby adversely affects cropping capacity. Where trees are attacked even to a small extent by such pests as aphides, red spider or caterpillars, or by the scab fungus, they cannot produce maximum crops of fruit, and even when the attack is too late to affect the current season's crop the following one is nevertheless adversely affected. Most farm orchards are partly defoliated each year by one or more of these pests, and a brief description of their *modus operandi* is desirable in discussing the spraying programme designed for their control.

Aphis or Green Fly.

Aphis is one of the most common orchard pests, and is often termed "blight." The small aphides increase during summer by producing living young. The females live on the under surfaces of the leaves and there give rise to large colonies of the insects. The insects feed by inserting their mouth parts into the tissues of the leaf and extracting the sugars and other materials which the leaves manufacture for the nourishment of the whole tree. As the result of this, the leaves become very much misshapen in appearance and frequently they are so much distorted as to be useless as organs for the manufacture of foodstuffs so necessary for the production of fruit. Since the aphides feed by inserting their mouth parts into the tissues of the leaves, they can only be controlled in summer by using washes or powders which kill by direct contact with the body of the insect. Nicotine, derris and pyrethrum are examples of contact insecticides used for this purpose, but, since the infested leaves are often so much curled, the practical difficulty of reaching the pest with the contact insecticide is considerable. The control of aphis during summer is therefore extremely difficult unless very powerful spraying equipment is available.

Fortunately this pest can be easily controlled by using an egg-killing wash during the dormant period. As autumn approaches the female aphides cease producing living young and deposit eggs instead. These they place in the small crevices and leaf scars at

the base of spurs and lateral buds. The eggs can be detected during the period December to March by the naked eye, or more easily with a lens, as small, round, black, glistening objects.

They can be destroyed by the application of an emulsion of tar oil distillate applied in winter. The introduction of this class of winter wash has rendered the control of aphis relatively simple and effective. A complete control of the pest is usually obtained by a thorough application of a wash consisting of $7\frac{1}{2}$ gallons of the tar oil concentrate diluted to 100 gallons with water. The wash must be applied before the buds begin to swell in spring, otherwise bud injury may occur.

Caterpillars.

The caterpillars which attack apple and pear orchards are the larvae of several species of moths, particularly the March and Winter Moths, and to a less extent the Tortrix Moth. The Tortrix and Winter Moths deposit their eggs in the small crevices of the bark, particularly in the younger parts of the tree, during the period late September to the end of January. These eggs hatch out into caterpillars in early spring. The March Moth, on the other hand, does not lay its eggs until late February or early March.

The eggs of all three species of moth hatch in early spring and the larvae cause considerable damage by eating the developing foliage. In cases of severe attack the first crop of leaves may be entirely destroyed. Two methods of control are available. One is preventive, whilst the other is applied when the pest has been discovered in spring.

It was noted above that the eggs of the Tortrix and Winter Moths are present on the trees during January and February. They are therefore amenable to treatment by an egg-killing winter wash. It has been found that the tar distillate washes at a 10 per cent. concentration, properly applied, will give a very high percentage kill of these eggs. These washes may be relied upon to give a commercial control of the above pests, but because of the protracted egg laying which takes place, winter washing should be supplemented by *grease-banding*. This consists of placing a band of sticky material round the trunk of the tree, for which purpose special banding substances are now available in commerce. The trees should be grease-banded in October and the bands should be freshened up twice during the winter, one of these operations being particularly necessary in February. The grease bands act as traps for the wingless females as they ascend the trunks for the purpose of depositing eggs.

In the case of the March Moth, which lays its eggs in February—usually after winter washing has been concluded for the season—the control measure consists of grease-banding and the use in spring of a lead arsenate wash. Lead arsenate is a stomach poison, and the object of applying it is to leave a heavy deposit of it on the foliage upon which the caterpillars feed. The wash is made by mixing four pounds of lead arsenate paste or powder into a thin cream and then mixing this into 100 gallons of water. This wash, which is poisonous to man when taken internally, should be applied against the caterpillars when all the eggs are hatched in spring. High pressures are most effective and a complete cover of all the foliage is essential.

Red Spider.

This is an increasingly important pest of the farm orchard. It is a minute insect, which by feeding on the leaves greatly reduces their value, causing them to exhibit an ashen grey appearance from July onwards. The over-wintering eggs are laid from July to September in the small crevices of the spurs and young shoots. These eggs are a deep, dull red colour and when present are easily observed by the naked eye during winter and early spring. The eggs hatch just before the blossoms open in spring and prior to hatching they assume a dull grey colour.

The pest is very easily controlled by a well-timed application of *lime sulphur*. The wash is prepared by mixing $1\frac{1}{2}$—2 gallons of the commercial lime sulphur into 100 gallons of water. Where the water is very hard, the efficiency of the wash may be increased by adding a small amount of a suitable " spreader." This wash must be applied in spring immediately after all the eggs have hatched, since it is only effective against the adult insects and has no effect upon the eggs. The red spiders begin to lay eggs about three weeks after hatching, and once egg laying has begun lime sulphur can no longer be used as a method of control. It is important therefore to apply the lime sulphur at the correct time.

Winter washes of the tar distillate type do not give any control of this pest. The addition of heavy petroleum oils to the winter wash mixture gives a partial control, although it is doubtful whether the increased cost incurred by the use of petroleum washes in winter for red spider alone is justified.

A control of this pest may be obtained during the *summer* by using a heavy petroleum wash. This wash is made by emulsifying heavy petroleum oils, of which several reliable brands are available, two gallons of the concentrated petroleum emulsion being added to 100 gallons of water. The wash can be applied any time during

the summer, but is most effective against the pest if applied during July and early August.

The application of a lime sulphur wash is undoubtedly the best and cheapest method of control. Since the eggs are hatching rapidly just before blossoming, the best time to apply the wash is just before the blossoms open. This may be called the " pink bud " stage of the blossoms. The wash must be applied in liberal quantities and with considerable force so that all the young foliage. the twigs and branches are thoroughly wetted. There is no danger from defoliation or bud damage by a lime sulphur wash at this stage. In cases where the infestation is severe and the above application has not given an adequate control, a second application of lime sulphur may be made soon after petal fall. Growers are warned that *post blossom applications* of lime sulphur may be followed by serious defoliation of certain varieties and these particular applications must be made with this possibility in mind. It is, however, not likely that more than a few varieties will be so sulphur sensitive as to be defoliated by a lime sulphur wash at one gallon in 100 gallons of water, applied immediately after petal fall, and this concentration could be made the starting point in trials of untested cases.

The Apple Sucker.

This insect is very common indeed on the trees of most grass orchards. Like the aphis it is a sucking insect and can be easily controlled by an egg-killing winter wash or by the summer use of a nicotine or similar contact insecticide. The eggs are dull yellow in colour and are laid in the leaf scars, principally on the fruit spurs. They hatch in early spring and the insects enter the opening blossoms and feed by sucking the sap from the blossom stems, thus causing the blossoms to wilt and turn brown in colour. In cases of very severe attack the damage and loss of crop may be considerable. This pest is the easiest of all to deal with by winter washing, and is now almost unknown in orchards that have been sprayed for a few years.

Apple Scab.

The fungus causing apple scab undoubtedly takes a heavy toll of the crops in some localities and especially of certain varieties of the highest vintage quality, notably Foxwhelp, Cap of Liberty and Kingston Black. A scab attack often reduces the effective leaf surface of a tree far more than most growers realize. In fact, where the disease gets a good hold before July, it may reduce the effective leaf area by over 50 per cent.

Scab is caused by a fungus which spends the winter in the tissues of the young one-year-old shoots. The presence of the fungus may be detected by small raised patches on the young shoots of apple trees during winter. It becomes active in early spring when it bursts open the small raised areas and liberates masses of minute spores into the air. Should any of these spores fall upon a leaf or young apple which is moist, and remains so for 12 to 24 hours, they germinate and penetrate into the tissues of the leaf or fruit. Soon afterwards dark sooty areas develop on the surface of the affected part and these areas constitute the typical " scab " attacks of the summer.

The control of Apple Scab cannot be undertaken in winter since at that time the scab fungus is in a well-nigh invulnerable situation. Furthermore, since during summer the fungus is in the leaves below the surface, it is almost impossible to control it at that stage. The objective in scab control is *to prevent infection from taking place* in spring and early summer, and for this purpose a protective covering of a suitable fungicide is employed. Lime sulphur and Bordeaux mixture are the two cheapest and most efficient fungicides for this purpose.

In order to obtain a *complete* control of Apple Scab, two or more spray applications are usually necessary and in special cases four applications may be required. These applications are timed so as to provide the young developing leaves and fruits with a continuous covering of the fungicide during the vulnerable period. In commercial apple orchards spray applications are made at the " green flower," " pink flower " and " petal fall " stages. Where very high-class dessert varieties are produced, additional applications may also be made in order to give a complete protection. The above times at best are approximations only and precise details should be obtained from the County Instructors or from this Institute.

Up to the present time, there has been very little spraying of cider apple orchards for the control of Apple Scab, and it is almost impossible therefore to give recommendations based upon actual experience or experiments in cider apple orchards. There is, however, a large body of experience available from commercial apple plantings which can be used in this connection. It has been found that where only one application of a fungicide can be made for the control of Apple Scab, the " pink bud " application is the most effective. This one application cannot be expected to give a complete control, but may be expected to materially reduce the amount of infection. Where a reasonable control is desired the " pink bud " application should be supplemented by the application at " petal fall."

It was pointed out earlier that certain apple varieties are extremely sensitive to sulphur. Fortunately, all varieties will withstand sulphur in any form up to the flowering stage. There is therefore no risk of defoliation or damage by applying lime sulphur *before* the flowers open. The " pink bud " application of lime sulphur is safe on all varieties. Post blossom applications of lime sulphur or Bordeaux mixture must be made with caution since it is not yet known which cider varieties are sensitive to these washes at this period. The " pink bud " application should be made with lime sulphur at a strength of 3 gallons in 100 gallons of water. Post blossom applications should be at $1\frac{1}{2}$ gallons lime sulphur to 100 gallons water.

The Application of Recognised Methods for Pest and Disease Control to Farm Orchards.

Spraying as a method of pest and disease control is an established practice in commercial apple orchards, and suitable technique and spraying materials have been evolved to efficiently deal with the various problems that are encountered. While the spraying of cider apple orchards has not as yet been extensively practised, the experience gained in commercial orchards may be used as a basis for coping with the spraying problems of farm orchards.

Spraying for pest and disease control is carried out at two distinct periods of the year, namely during the dormant period, December to March and in the actively growing period, May to September. The winter spraying is almost entirely directed against the eggs of various insect pests, whereas the summer sprayings are directed against larval or adult insects and fungus diseases such as scab.

1. *Winter Spraying.*

It has been mentioned that the eggs of the Apple Aphis, Winter and Tortrix Moths, and the Apple Sucker are all present on the tree during the period December to March and that these eggs are killed by applications of a suitable tar oil winter wash. Since in practice these pests account for most of the direct injury to the leaves, it is obvious that winter washing should result in a much better foliage upon the trees. That this is the case is easily demonstrated by observing sprayed and unsprayed orchards. It is suggested that orchards which have not been previously sprayed should be sprayed with a tar oil winter wash at 10 per cent. concentration. If properly applied this washing, in the season following the application, will ensure a large and adequate leaf surface upon the trees, and this condition should be followed by a much more profuse blossoming in the succeeding spring. After the first

season's winter washing, subsequent washings may be carried out at 7½ per cent. concentration. The most potent fraction of the tar oils used for this purpose is that which distils over at a temperature between 280° and 360° C. This fraction is very difficult to emulsify and care should be exercised to purchase a reliable wash. Numerous commercial preparations of such washes are now available.

2. *Grease Banding.*

In localities where the March Moth is prevalent, grease-banding should also be practised since winter washes must be applied before the eggs of this particular pest are laid. With mature trees the grease-banding material may be applied to the trunks. For young trees it is preferable to tie grease-proof paper round the trunk and apply the grease-band material on to this paper. The trees should be banded in October and the bands should be " freshened " once or twice during winter by running a wide toothed comb or some similar tool round them. Particular care should be paid to have the grease bands freshened in February and March, since at this time the female March Moths are ascending the trees for the purpose of laying eggs.

3. *Lead Arsenate Washes.*

Lead arsenate is a stomach poison, and may be purchased in powder, paste or liquid form. The last is known as " Colloidal " lead arsenate, and is a specially prepared suspension of lead arsenate particles, in water. It is convenient to use since the requisite amounts may be measured out. It also has the advantage in that its particles are extremely small. A suitable wash is made by mixing four pounds of the powder, paste or " Colloidal " lead arsenate into 100 gallons of water. When using powder or paste the material must first of all be made into a " cream " by mixing with a small quantity of water. The wash should be applied with considerable force and a complete cover of all leaves must be obtained. The wash is used against caterpillars and any insects or larvae which eat the foliage. The wash is poisonous when taken internally, and care must be exercised in its use, but it does not cause any damage when falling on the skin. Lead arsenate powder or paste may be mixed with lime sulphur or Bordeaux mixture, but it is not advisable to mix colloidal lead arsenate with lime sulphur, since a reaction takes place whereby soluble substances are formed which cause scorching of the foliage.

4. *Lime Sulphur.*

Lime sulphur is one of the easiest of washes to use. It is prepared

by boiling together quick lime and sulphur in certain proportions. It is made commercially on a very large scale, and an excellent standardised product is obtainable. The important ingredient is "polysulphide," the content of which should not be less than 25 per cent. on a weight in volume basis. The concentrate is diluted with water for use as a wash.

5. *Bordeaux Mixture.*

In contrast to lime sulphur, this is a wash which is best made on the farm. It is most easily prepared by dissolving 50lbs. of copper sulphate, 98 per cent., in 50 gallons of water in a wooden tub. This makes a "stock" solution of copper sulphate containing 1lb. per gallon of water. A similar stock solution of lime is made by dissolving 50lbs. of quick lime in 50 gallons of water. The spray fluid is made by adding 4 gallons of the copper sulphate "stock" and then 5 gallons of the lime stock to 31 gallons of water. This makes 40 gallons of wash. The final mixing should be made just before the wash is applied since on standing the small particles tend to settle out. This wash is used at half the above strength as a post-blossom spray.

6. *General Observations.*

The application of the above washes must be thoroughly carried out, since the materials cannot be effective if they are indifferently applied. In the case of a winter wash, it is essential that all the eggs are wetted and, as these are often in the small crevices, the wash must be applied with considerable force. The lead arsenate, lime sulphur and Bordeaux washes are intended to cover all the young foliage and fruit so that a deposit or film of the substance remains covering these parts. To achieve this end adequate pressure and the use of ample amounts of wash are essential. Finally it is impossible to apply these washes economically and effectively without spraying equipment of adequate size for the undertaking in hand.

Spraying Machines and Equipment Suitable for Use in Farm Orchards.

A large number of different kinds and makes of spraying outfits are now available. They range from the large power spraying plants costing two hundred pounds or more to the small hand operated pumps costing twenty pounds. The small knapsack sprayers which are also made are not at all suitable for spraying large standard trees and therefore will not be discussed here.

1. *Power Spraying Machines.*

It was stressed earlier in this paper that the washes used in disease and pest control must be applied with considerable force if they are to be effective. This means that the wash must be applied under a pressure of not less than 200 pounds per square inch. To maintain these high working pressures, power plants are essential where the trees are large or the area to be sprayed is extensive. There are a number of different makes of power spraying outfits available, ranging in size from the large units capable of delivering 18—20 gallons per minute at 350lbs. pressure to the small power units capable of applying 4 gallons per minute at this pressure. The large machines may appear expensive, costing £200 to £250, but they deal adequately with extensive areas and with very large trees, and hence are economical units for large scale work.

During recent years several very small power spraying machines have been introduced. These are fitted with small engines, mostly of the motor cycle type, and are usually designed to give a working pressure of approximately 200—250lbs. per square inch.

It is necessary at this point to emphasize the fact that a spraying machine is essentially a pumping mechanism, and as such its efficiency will be limited by the efficiency of the pumps. These latter must also be supplied with a power unit capable of taking the maximum load which the pumps will carry. When purchasing a spraying machine it should be remembered that under field conditions the efficiency of the outfit will fall rapidly. The result of a bench test of engine and pumps is an ideal statement of capacity. Under actual field conditions the engine and pumping capacity may be reduced by 25 per cent or more. The design of both pumps and outfit is important, and facilities for obtaining spare parts for pumps and engine at short notice must not be overlooked.

Furthermore, it has been found that the measure of efficiency in a spraying outfit is to be found in the relationship that exists between the working pressure and the volume of liquid which the pumps will supply at this pressure. Thus while high pressures are essential for efficient spraying, there must also be an adequate supply of liquid available at these high pressures. The importance of this point will be evident when spray nozzles are discussed. Because of this very important consideration spraying machines should be carefully tested with regard to it before purchase. Engine power and working pressure, considered apart, give no guide to the efficiency of the unit, the really important feature being the number of gallons of spray fluid which the pumps will deliver *per minute* at any given working pressure. It is well known, of course, that all force pumping mechanisms can be made to work

at high pressures, but it almost invariably happens that in achieving this end the volume of liquid which is pumped must be reduced. On the other hand, when large volumes of liquid are required under high pressures, adequately sized pumps and ample engine power are essential. A common fault of spraying units is that they are not fitted with engines of adequate power.

2. *Spray Guns and Lances.*

The above general points concern the actual pumping machinery. Having obtained the spray fluid under pressure, it may be delivered from the machine through the delivery hose piping on to the tree by means of " spray guns " or " spray lances." These are essential parts of spraying equipment, and since opinion is divided upon their relative efficiency, the particular points in connection with each of them are discussed below.

Spray guns are short metal appliances attached to the delivery end of the hose piping and contain the nozzle mechanism. They are designed to work at comparatively high pressures, and will not work efficiently at pressures of less than 250 pounds per square inch. In fact, thay are not really suitable for use at a working pressure of less than 300 pounds per square inch. The spray gun depends for efficient action upon delivering a relatively large volume of liquid at a very high pressure. It is absolutely essential that both factors are present at the same time. By delivering large volumes of liquid, they reduce the time taken to apply any given volume of liquid as compared with spray lances. and in this way the use of spray guns may reduce spraying costs. Men who are used to spray lances, when spraying with guns, usually do not move quickly enough over the tree and thus use a very large volume of liquid and increase rather than decrease the cost of spraying. On the other hand, it is not enough merely to "shoot " a jet of liquid at a tree and to consider the latter adequately sprayed. The design and construction of a spray gun through its adjustable nozzle allows of a variable spray, ranging from a coarse jet to a fine mist. This variable spray is under the direct and easy control of the sprayer and by its proper employment trees of all sizes can be sprayed effectively and quickly. With tall trees it is necessary to use a large nozzle orifice and very high pressures. In fact, the taller the trees the larger must be the nozzle orifice and the greater the working pressure if the work is to be done quickly and economically.

Spray lances as contrasted with spray guns employ a fixed nozzle which may be set to deliver either a fine or a coarse spray, or a large or a small volume of liquid. These settings require the

operator to stop work in order to make the necessary adjustments. Nozzles such as are commonly employed in spray lances give a spray composed of very fine drops. These drops are usually much smaller than those delivered from a spray gun, and they travel with much less velocity. Spray nozzles, in fact, are mostly designed to give a " fine " spray. Such nozzles are very economical of spray fluid, but the time taken to spray a tree is thereby increased. This may be counteracted to some extent by using discs with larger holes. Spray nozzles for use on lances may have a single or a battery of three or four nozzles set upon a common frame work. These nozzles do not usually give a penetrating spray and are therefcre of necessity mounted upon long bamboo or aluminium handles which may be as long as ten to fourteen feet, the latter length being absolutely essential for the spraying of trees eighteen feet high. Spray lances are designed to work at comparatively low pressures, and they work equally well at pressures varying between 80 and 200 pounds per square inch.

It is evident that the use of spray guns is limited to those occasions where large volumes of liquid and comparatively high pressures are available. The spray lance can do quite good work so long as its limitations are understood and allowed for. It must always be worked very close to the parts being sprayed since there is but little velocity in the spray after it leaves the nozzle.

With the above considerations in mind regarding pumps, engines and spraying nozzles, growers can select machines which are best calculated to meet their requirements. It was mentioned earlier that during recent years a number of small power units have been introduced. These are fitted with 1 to $2\frac{1}{2}$ horse power engines which are designed to give a working pressure of 250lbs. per square inch. These machines are at best capable of working two lances or one gun, and under field conditions many of them are unable to maintain a working pressure above 180—200lbs. when two guns are in use. They are, in fact, comparatively efficient " one gun " or " two lance " machines. These machines sell at prices ranging between £65 and £80. Intending purchasers should seriously consider the relative merits of the various machines in this class since they are almost invariably very near the border line between one and two gun outfits. Spraying outfits must be purchased upon their capacity to deliver liquid under pressure and, since spray guns have been shown to be more economical in the long run, they should be tested in connection with a proposed new machine. A machine which will work two spray guns will also work two lances, and in many cases even four, but the reverse is by no means true. It will be clear that a machine costing say £80 which is capable of

maintaining two guns in continuous use is a much more profitable investment than one costing £65—£70 which will only consistently maintain one gun. The one will enable the grower to do twice the amount of work in the same time without any appreciable increase in working costs except, of course, the additional man with the spray gun.

3. *Manually Operated Spraying Plants.*

It cannot be too strongly emphasised that power plants alone are able to deal economically and effectively with large standard trees in grass orchards. It is realised, however, that in some cases growers who are not in a position to employ a power plant may wish to carry out a spraying programme. In this case some form of manually operated pump may be used. A common form of manual pump is known to fruit growers as a "Headland Pump." In this form it is usual for a pump to be fitted on to a wooden platform mounted on two wheels in order to facilitate movement from place to place. Machines of this type complete with rubber pipes and spray lances cost £15 to £25. They are almost invariably suitable for use with spray lances *only*, since apart from the exceptional case referred to in the next paragraph they do not give enough pressure for use with spray guns. An equipment of this type with two men pumping and two spraying will do about an acre a day.

Several variations of this type of sprayer are available. One make has a pump quite capable of developing and maintaining 200lbs. pressure, the pump being fixed on to a metal container and the whole mounted on a hand trolley. Of the manual units at present available this is one of the best. It costs about £28 to £30 complete and will work two spray lances or one spray gun.

Such units as the above are cheap and reasonably efficient, considering their obvious limitations. For spraying farm orchards they can be utilised but are by no means ideal. It is always possible to adapt them in order to increase spraying efficiency. For example, the machine may be placed on a lorry or in a farm cart and operated thus from a more elevated position. In this way the unit is raised three feet nearer its work.

Contract Spraying.

The importance of spraying farm orchard trees is being realised more and more, and some of the more enterprising farmers are purchasing power spraying outfits for the purpose of contract spraying. In the Sparkford-Cadbury area of Somerset there are

now two small power machines available for hire by farmers. Machines on this system are also working in Devon and Cornwall, and recently two large machines available for contract spraying have been introduced into Herefordshire.

These plants are mostly owned by large farmers or cider apple growers and have been bought primarily to spray their own holdings. When engaged upon contract spraying they operate upon different bases according to the individual owner. A number of the plants are working upon the basis of the number of gallons of concentrate used. Thus, the contractor supplies machine, two men for spraying, and the winter wash concentrate, whilst the farmer provides the water and the necessary equipment and men to cart the water to the spraying machine. For this service the contractor charges from 4/- to 4/9 per gallon of concentrate used. Other contractors charge a flat rate per hour for the hire of the machine and two men, and allow the farmer to purchase his own winter wash and supply water.

The nett cost of spraying under these conditions will obviously vary with the different contractors, and it is difficult to estimate such costs. The cost would naturally be affected by the strength and the amount of the wash used, particularly where the price for spraying is based upon the number of gallons of concentrate used.

Increasing the number of machines available for contract spraying would contribute substantially towards solving the problem of spraying West Country orchards as many farmers appear to be willing to pay for having their orchards sprayed, whereas they are not prepared to invest capital in purchasing machines and equipment. The contract sprayers in Somerset were fully booked up for the 1932—33 season, and one contractor who started his spraying programme with a manual equipment found it necessary to invest in a power equipment in order to fulfil his engagements. Particulars of these machines can be obtained from the County Instructors for Horticulture or from Long Ashton.

The Cost of Spraying Cider Trees.

Spraying costs may vary within very wide limits, depending upon such factors as personal management, distance from the water supply and kind of equipment used, whilst the cost of spraying orchards is difficult to determine since comparatively few farmers keep the necessary records from which accurate costing can be ascertained.

In the Annual Report of this Station for 1928, data are given

relating to the costs for spraying 120 standard apple trees in grass. These trees comprise part of the cider apple orchard at Long Ashton planted in the winter of 1903–4, and are typical of farm orchard trees. The equipment used at Long Ashton is a four-horse power plant capable of working at 250lbs. pressure, and the machine is adequate for two guns or four lances. In the costed spraying the machine was drawn along under the trees by tractor and spray fluid carted to it. Spraying in every case was carried out by means of guns. The spray used was a standard tar oil winter wash applied at 7½ per cent. concentration, and for purposes of calculating costs the concentrate was charged at the current market price.

Using the above equipment and materials the cost of winter spraying in 1928 worked out at about 1 3 per tree. This cost was based upon the amount of wash used, time taken to apply it, the petrol and oil consumed by the engine and the carting of the water. It did not include wear and tear of plant, replacements of rubber hose, interest on capital or foreman's supervision. The additional cost which must be added for these latter items is difficult to determine, but a charge of threepence per tree should be adequate. This would bring the total cost to about 1 6 per tree. Thus for an orchard about that age with the trees planted at 30ft. apart each way, giving 48 trees per acre, the cost per acre would work out at £3 12s.

In the Station Report for 1929, data are given for spraying the whole of the cider orchard at Long Ashton and in this case the cost, calculated as above, worked out at 1/- per tree. Allowing for wear and tear and replacements the cost would amount to 1/3 per tree. In this case all the orchard was sprayed and as there have been a number of replacements from time to time some of the trees are very small. The price compares very favourably with that obtained for the 1928 spraying.

The orchard was not sprayed in 1930, so that figures for that year are not available. In 1931, when the orchard was once more sprayed, the cost again was approximately 1/- per tree for the whole orchard. This with the cost of wear and tear would be about 1/3 per tree, or £3 per acre.

It is evident then that, as a general figure, the cost of spraying average sized orchard trees with a winter wash at 7½ per cent. concentration will be about 1/3 per tree for labour and materials as above. This figure must be regarded as a *minimum* obtained by using a power plant, spray guns and well organised labour. It would necessarily have to be increased in the case of very big trees or where the orchard conditions present difficulties

or the spray fluid is used at 10 per cent. instead of at $7\frac{1}{2}$ per cent. concentration. Where machines have to be transported the cost per tree would again be somewhat increased.

For the purpose of the present discussion, the cost has been worked out as cost per tree rather than cost per acre since very few cider apple orchards are fully planted with trees. It will be realised that a complete acre of trees will cost much more to spray than an acre where six or seven trees are missing. Where trees are planted at 30ft. apart, even five trees missing per acre represents a tenth of the possible number per acre.

The amount of wash used varies with the size and variety of the tree. Large trees, of the size of a full-grown Bramley of thirty years old, will require seven to ten gallons of wash per tree. When using lances it is possible to " cover " the tree with less spray liquid than when using guns, but the time taken to do the work is very much increased. Hence for large trees the figure would be seven gallons per tree when using lances as against ten gallons per tree when spray guns are employed. From these figures growers can estimate their probable requirements of winter wash concentrate. For most purposes the winter wash can be used at $7\frac{1}{2}$ per cent. concentration, so a 40 gallon barrel will make 530 gallons of diluted wash. Even for very large trees this will be quite sufficient to spray an acre of trees.

The Economics of Spraying.

It has already been clearly established that the control of Aphis, Caterpillar and Apple Scab increases the yields from commercial fruit plantations. In fact, it is one of the essential requirements to profitable intensive fruit culture. Data showing the increased yields of cider orchards resulting from a satisfactory pest and disease control are not available. There is, however, a large body of experience which may be used to substantiate the claim that winter spraying is a profitable undertaking. Perhaps the best evidence that can be offered is the fact that growers who have once used a winter wash almost invariably continue in its use.

As regards the actual increase of the cider apple crop due to winter spraying at Long Ashton data are not available. The cider apple orchard has been sprayed each year since 1928 with the exception of 1930. This orchard is about four acres in extent, but is not completely covered with trees. Several varieties have not proved profitable for this locality and a row of plum trees previously ran across the middle of the plot. The yield of fruit from this

orchard has been as follows :—

1929	.. ..	20 tons
1930	.. ..	14 „
1931	.. ..	13 „
1932	.. ..	8 „

Calculated upon an area basis this gives an average yield of approximately 3 tons 15 cwts. per acre for the four-year period.

The low yield in 1932 was in all probability due to a combination of factors. There is no doubt the omission of the winter spray in the winter of 1931-32 contributed to some extent, but the main factor was the unfavourable weather which was prevalent at blossoming time. The year 1932 was also conducive to the development of the Apple Scab fungus and many trees were very seriously affected.

General Recommendations.

It remains finally to raise the general question of the spraying programme necessary to ensure good crops. It is difficult, if not impossible, to make any invariable rule. Individual conditions and local considerations are very large factors. It may be safely asserted that where trees have not been sprayed at all previously they will be very much benefitted by the application of a winter wash at 10 per cent. concentration. This if correctly applied will give a control of Aphis, Caterpillar and Apple Sucker, and as an additional protection the trees should be grease-banded in October and the bands freshened up in February. In most cases this treatment will bring about a great improvement in foliage and cropping. In subsequent years the winter wash may be used at 7½ per cent. concentration. Winter spraying is undoubtedly the first and most essential spraying requirement of the farm orchard.

Where the control of Apple Scab and Red Spider is also desired, the orchard should be thoroughly washed in spring with a lime sulphur wash at a concentration of three gallons to 100 gallons of water. This wash should be applied at the " pink bud " stage of flower development. If by any chance there is an infestation of caterpillars three pounds of lead arsenate should be added to the lime sulphur wash.

The combined cost of winter washing and the one application of lime sulphur for Apple Scab and Red Spider should not exceed 3/6 per tree. In many cases the cost may be not more than 2/6 per tree.

It is not suggested that cider apple orchards should be given the above spraying programme every year. In a light crop year the scab spraying may be omitted. In fact, growers might seriously

consider alternating winter washing with summer washing. Obviously very old and dilapidated orchards will not repay the expenditure of spraying. On the other hand, many orchards exist which have a large potential bearing surface which could be made productive by the adoption of a regular spraying programme.

Groups of farmers might consider the purchase of a spraying machine in localities where contract spraying is not available. In any case, it is better to thoroughly spray one half of the orchard than to spray the whole orchard ineffectively.

The County Horticultural Instructors and the Staff of the Institute are always prepared to advise growers concerning any of the above problems, and growers should consult them upon their own particular orchards and spraying problems.

EXPERIMENTS WITH COMBINED INSECTICIDE-FUNGICIDE SPRAYS FOR APPLES.

PROGRESS REPORT.

By H. G. H. Kearns, R. W. Marsh and T. J. P. Pearce.

A.—INTRODUCTORY.

The desirability of simplifying the programme of spray applications on apples needs no stressing. The various sprayings now necessary to ensure the production of clean fruit make up a formidable catalogue, complicated by the presence of certain pairs of sprays—the one insecticidal and the other fungicidal—which are due for application at approximately the same date, but, being chemically incompatible, must be applied separately. This separate application, necessitating an interval between the two sprayings, is frequently prejudicial to the effectiveness of one of them : could the insecticidal and fungicidal properties be combined in a single spray, both would be exerted at the optimum time. In addition, as published data show that approximately half the cost of a summer spraying is due to expenditure on labour, the financial benefit of a combined spray is obvious.

In the early years of tar oil distillate spraying, it was hoped that such a measure of insect control would be obtained by winter washing that spring and summer treatments would be little required except for fungus diseases. But the effect of the winter washes developed up to the present has been not so much in solving the problems of pest control as in presenting them in a different order of importance. Aphis and sucker are no longer in the foreground, but their place is taken by sawfly and red spider. The supplementing of winter sprays by spring and summer treatments remains necessary, and the coincidence of seasons of intense sawfly and spider attack with periods in which apple scab has been unusually difficult to control has made the need for new combined sprays particularly acute.

This paper is concerned only with apples, and the varieties considered will be limited to those commercially grown on a large scale, namely, Allington, Annie Elizabeth, Beauty of Bath, Bramley, Cox, Early Victoria, Edward VII, Grenadier, Grieve,

King of the Pippins, Lane, Newton, Ross, Stirling and Worcester. The sprays discussed are for spring and summer applications (roughly, those applied from March to September); thus, all types of winter wash will be excluded from detailed consideration. Similarly, the pests and diseases dealt with are those which are commonly controllable by spraying during the growing season.

TABLE I.

PROGRESS OF BLOSSOM BUD OPENING AT LONG ASHTON, 1932.

Troubles such as apple blossom weevil and canker do not come under this heading and are therefore ruled out.

The terms used for the stages of blossom bud opening are those put forward by Briton-Jones and Lees; namely, "Swelling," "Bursting," "Burst," "Green Flower," "Pink," "Full Blossom" and "Petal Fall." Illustrations of the first four of these stages are given in Table I, which records the progress of blossom bud opening in fifteen varieties at Long Ashton during March, April and May, 1932 (a season somewhat later than normal). It is noteworthy that the variations in the date of reaching the earlier stages are almost entirely levelled up by the time the pink stage is attained, Annie Elizabeth and Edward forming the only exceptions.

To place the problem of combined sprays in its proper setting, it was thought advisable to give a brief conspectus of the factors determining the existing programme of spring and summer applications. These are considered in Section B below, while the observations on the development of new combined sprays follow in Section C.

B.—THE EXISTING PROGRAMME OF SPRING AND SUMMER APPLICATIONS.

1. Pests and Diseases Controllable by Spring and Summer Treatments.

(*a*) *Sucking Insects.*

(i) *Aphides.* The species of aphides found most commonly on apples are the Blue Bug (*Anuraphis roseus*), Rosy Apple Aphid (*Anuraphis crataegi*) and the Woolly Aphid (*Eriosoma lanigera*). The first-mentioned species is more generally distributed than *A. crataegi*, and if present in appreciable numbers in a plantation causes very serious damage to the leaves, shoots and fruitlets, not only by feeding on the plant juices but also by covering the foliage with sticky secretions. *A. crataegi* is more usually associated with damage to foliage, which is turned a characteristic yellowish-pink colour. Both species lay eggs in autumn at the base of buds on apple shoots. The black, shiny eggs hatch in March and April as the blossom buds are bursting. The aphides assemble on the outside of the bud, and as it opens they enter between the leaves and in a short time each aphid produces a number of nymphs. If the atmospheric humidity and temperature are comparatively high, subsequent reproduction is very rapid and a small number of mother aphides may form the nucleus of a severe attack.

Apart from killing the eggs in winter, these two species are most effectively dealt with at the green flower stage, when the eggs are all hatched but the aphides are not yet so completely esconced within the bud as to be inaccessible by a contact spray. If the attack is slight, a post-blossom application under favourable climatic conditions will provide a control.

Woolly Aphid is a serious pest on some varieties of apple such as Cox and Worcester, particularly if a humid atmosphere prevails for any length of time in late summer. The attack develops in late July after the period of migration of the root form of the aphid, or, in the West of England, from the overwintering stem form. Migration of apterous aphides from the root may be prevented by banding in July, but there is not an entirely satisfactory method of controlling a severe stem attack. An appreciable check, however, can be obtained by the use at the end of July of a contact wash with an effective wetting agent.

(ii) *Apple Sucker* (*Psylla mali*). This is one of the most abundant apple pests. The eggs are laid in autumn on the fruit spurs and hatch in late March or April. If the nymphs are numerous, considerable damage is done to the unopened flower buds which become so weakened that they fail to set fruit. The eggs of this pest are relatively easily destroyed by tar distillate washes and a satisfactory kill of the insects can be obtained by a contact wash applied at the early pink stage.

(iii) *Red Spider* (*Oligonychus ulmi*). During the past few years and following the extensive use of tar distillate washes, Red Spider has become a serious pest. The eggs are laid on the shoots of apple in autumn and the majority are hatched by the time the buds reach the pre-pink stage in the following spring. By the second week after petal-fall, summer eggs are laid on the lower surface of the leaves, and several generations of mites are produced in a season.

The winter eggs are amenable to control only by a smothering wash applied just before hatching. The periods when most effective control of the mites on the foliage can be obtained are first at the pink stage and secondly not later than a fortnight following petal fall.

(iv) *Capsid Bugs.* The two species of capsid usually responsible for injury to the apple are the Apple Capsid (*Plesiocoris rugicollis*) and the Green Capsid (*Lygus pabulinus*). The former species is single-brooded in a season and the eggs are laid principally in the bark of young apple wood in late June or July. A number of eggs are hatching or near hatching at the end of April, and the majority

have hatched by the pink stage. The nymphs puncture the young foliage and fruitlets and the insects remain feeding on the tree until late June or early July when they are fully grown and winged.

The eggs are increasingly sensitive to the effect of smothering washes as they approach the hatching stage. A few capsids can cause a considerable amount of damage to fruit and for this reason any egg-killing treatment should be supplemented by a later contact wash to "clear up" the surviving nymphs. With this wash, the most effective control is obtained at the pre-pink stage and again just after petal fall.

The Green Capsid is double-brooded in a season and is a pest of complicated life history and great activity. The winter eggs are laid in the bark of a number of woody plants including the apple, and they hatch later than those of the apple capsid. The nymphs cause extensive foliage and shoot injury and possibly on some varieties of apple the punctures on the fruitlets may develop into scars, but the evidence for this is circumstantial. Before the nymphs are full-grown, they migrate to various species of cultivated plants and weeds, and on these the adults lay their summer eggs. From about mid-July until September the adults of the second brood migrate to various woody plants, and at this period a sudden appearance of fresh foliage damage on the apple is not uncommon, followed perhaps by late pitted markings on the fruit.

It is in mixed plantations or in those near currants and gooseberries that the green capsid is most prevalent. On account of its late hatching the pest is most susceptible to control on the apple in the post-blossom stage. An effective control of the capsid at this period will help to reduce the intensity of the attack of the returning winged forms later in the year. Applications of a contact wash when the capsids are present on the apple after mid-July will materially reduce their numbers, although when the migration occurs over a protracted period more than one application will be necessary.

(*b*) *Biting Insects.*

(i) *Apple Sawfly* (*Hoplocampa testudinea*). The varieties Ross, Worcester, Cox, Newton and Grieve are highly susceptible to attack by this pest, and it is not unusual for an almost total loss of crop to occur where control measures are not adopted. Normally one egg is laid per blossom, and it is deposited in the receptacle beneath the calyx cup, a characteristic rusty mark denoting the site of oviposition. The eggs hatch during the two weeks immediately following petal fall and the success of a control measure depends on killing the maximum number of nearly-hatched or

newly-hatched larvae. The date of hatching (expressed as the number of days after petal fall) depends upon the variety of apple, the duration of oviposition and the incubative period of the eggs. Accurately timed contact washes have provided a high measure of control, but where hatching is protracted, it may be necessary to give more than one application of a contact wash or even to use a stomach poison to extend the duration of toxicity.

(ii) " *Caterpillars.*" The term " caterpillar " includes the larvae of several species of moths, of which the Winter Moth (*Cheimatobia brumata*), Mottled Umber (*Hybernia defoliaria*), March Moth (*Anisopteryx aescularia*) and the Tortrix Moth are the most important. These moths lay their eggs on the twigs at the base of buds and the larvae hatch out at the time of bud burst and continue to feed on the foliage until May or June. If the infestation is severe, complete defoliation of the tree may result. There are usually larvae of the March Moth and some larvae of the other species that survive winter egg-killing treatments, and these may be killed in greatest number by a stomach poison wash applied at the pink stage and again at petal fall. Newly-hatched caterpillars will also succumb to a contact wash.

(*c*) *Fungi.*

(i) *Scab.* In general, scab is the one fungus disease of apples against which spraying is regularly practised. Of the varieties listed in Section A of this paper, Cox, Grieve, King of the Pippins and Worcester are highly susceptible to scab, and, of the remaining varieties, there is not one on which scab spraying can safely be omitted. The control of scab presents peculiar difficulties in that attacks of the disease are possible at any period from the bursting of the buds until the autumn, whilst the infections once established in the tissues are not vulnerable. Primary infections may come either from pustules on the one-year-old shoots, from spores ejected from the over-wintered leaves, or from infected bud-scales. From these sources, spores are carried in wind-blown rain to leaves, young shoots or fruits, initiating, in conditions favourable to the fungus, new pustules which act as centres of further infection. It can in fact be stated that attacked trees are never free from spores throughout the growing season.

Obviously such a disease is less likely to be controlled by a single spray application than by a series of sprayings designed to maintain a protective film on the foliage and fruit. The timing of the sprays is based on the facts that young tissues are most easily infected and that infection can take place only on a surface that remains wet for several hours. Thus the showery periods during

April and May, when the blossom buds are unfolding, are times when the tree is specially susceptible to scab infection. Again there is a period of particular liability to infection in June when the young fruits are setting and the buds on the vegetative shoots are opening. Control measures are therefore aimed primarily at protecting the tree during these stages of special vulnerability, and, as the tree passes through these stages relatively rapidly, the ability to make the spray applications promptly and speedily is of the first importance.

(ii) *Mildew.* The attacks of apple mildew are most conspicuous on the leaves, but the disease also attacks blossoms and shoot tips. The mildew fungus hibernates within the buds, the diseased buds opening in the spring to produce mildewed trusses. From these a certain amount of secondary infection on to healthy leaves—and thence to buds—takes place from May onwards. While no spraying treatment will prevent the opening of infected buds into mildewed trusses, there is an opportunity of keeping the disease in check by arresting secondary spread. A distinct programme for mildew control is not commonly put into operation, but in drawing up the scab spraying programme, attention is also paid to the claims of mildew control, particularly on the varieties Cox, Lane, Allington, Stirling, Newton and Annie Elizabeth, which are particularly susceptible to this disease.

2. Insecticides and Fungicides in General Use.

(*a*) *Winter Washes.* An account of winter washes falls outside the scope of this paper, but certain effects of winter washing have to be considered in connection with spring spraying. After a winter application of a 10 per cent. tar oil distillate emulsion, for example, it may be assumed generally that a tree will be almost freed from apple sucker and aphid, although at times aphid control is not entirely satisfactory, "caterpillar" will be largely reduced and apple capsid somewhat lessened, but red spider eggs will be unaffected.

Winter application of a $7\frac{1}{2}$ to 10 per cent. petroleum oil emulsion will give no control of aphid or sucker but will reduce red spider and give good control of apple capsid and caterpillar.

There is also a secondary effect of the continued use of tar oil distillate emulsions in increasing the development of red spider by killing its predators. Again it appears that one of the factors responsible for the recent increase in attacks by apple sawfly is the general reduction in summer spraying consequent upon the use of winter washes.

(*b*) *Nicotine.* Nicotine is commercially available in two forms, free nicotine and nicotine sulphate. The free form is almost exclusively used in this country, either as a wash or as a dust, the former providing much more satisfactory results. The wash consists of nicotine, soap and water ; it is important that free soap shall be present to act as a spreader of the toxic material, and larger quantities are required for hard waters. Very hard waters render the use of normal soaps impracticable, but the recent introduction of certain proprietary wetters, such as Agral I, Lethalate Wetting Preparation, etc., which under all conditions possess better wetting powers than soaps, has overcome this difficulty. Nicotine is essentially a contact wash and it is imperative that it should be used in conjunction with a good spreader. Two concentrations are commonly used, 4—6 fl. oz. per 100 gallons water for the control of aphid and sucker, and 8—10 fl. oz. for capsids, larvae of apple sawfly and small " caterpillars." Nicotine does not control red spider.

The higher concentration of nicotine does not cause any damage to the foliage or fruitlets, but too high a concentration of the spreader may cause some injury. On account of the fumigant action of the nicotine on the respiratory system of the insect, the best results are obtained when it is applied during comparatively high atmospheric temperatures, indifferent results occurring below 55°C. The duration of effective toxicity after application is very short and normally only a matter of hours.

The majority of the dusts consist of varying quantities of free nicotine incorporated in either the so-called " colloid " or crystalline carrier, the latter being apparently the more effective. Dusts are not well suited for application to apples as a means of controlling a severe attack of a sucking insect, frequently giving unsatisfactory results.

(*c*) *Arsenicals.* Lead arsenate and calcium arsenate washes are commonly used for the control of mandibulate insects attacking plant tissues. In this country lead arsenate (in which diplumbic hydrogen arsenate predominates) is used in three forms, powder, paste and colloidal, which differ from each other in their physical state and content of total arsenate. The lead salt is insoluble in water and very heavy, and for the latter reason it is important that the particle size should be as fine as possible in order to obtain a suspension that may be applied uniformly on the foliage, etc. The colloidal form provides the most even cover, and generally the paste is better than the powder. The spreaders gelatine and calcium caseinate are frequently added to the washes in order to improve the suspension, spreading and adherence of the particles. Soaps

cannot be employed on account of the formation of lead " soaps." Agral I and Lethalate Wetting Preparation are suitable, but it is essential that the amount added to the wash is carefully regulated, as an excess causes the failure of the lead arsenate to adhere to the foliage. The amount required varies with the type of foliage and arsenate. The quantity of arsenate required to control " caterpillars " attacking apple foliage varies with the type of preparation, and ranges from 2—5 lb. per 100 gallons of water.

Calcium arsenate is not used in this country, although extensively employed in U.S.A. There is some liability of causing foliage damage unless the wash is carefully prepared.

Lead arsenate dusts are used, though not extensively, for the control of " caterpillars " on apples, but the results are not entirely satisfactory. The application is most unpleasant and not without some risk of causing arsenical poisoning of the operators unless precautions are taken.

(*d*) *Oils.* The employment of the vegetable oils as insecticides has progressed little beyond the experimental stage, but the insecticidal properties of the mineral oil emulsions as summer contact washes have been recognised for some years, particularly in America. They have not been used in this country to any extent, principally on account of their limited range of toxicity at the low concentration that may be used on apple foliage. The main reason for foliage damage has been the use of numerous grades of oils from different sources, and the results are at great variance even when oils of similar specification are used. There is not a satisfactory method of defining the constitution of a safe oil, but it is evident from experiments in U.S.A. and this country that the refined oils with a low content of unsaturated hydrocarbons and medium viscosity—the so-called white oils—are the least likely to cause serious foliage injury. A 5 per cent. emulsion prepared from an oil of this type (*e.g.* Shell " P_2 " oil) is highly toxic to the eggs of red spider and of capsids if applied just before they hatch, and at 1—2 per cent. concentration it provides a high control of red spider nymphs and adults and some control of aphid. The control of red spider by means of the lower concentration of the emulsion is of considerable value on those varieties susceptible to sulphur damage.

In parts of U.S.A. summer oil washes have established themselves in the spray programme. They provide a control of red spider, scale insects, and, in conjunction with lead arsenate or nicotine sulphate, a control of the Codlin Moth. In the Western States and in the Western Provinces of Canada lime sulphur and sulphur dusts are used for the control of apple scab, and it has been found

that extensive foliage damage results from the application of summer oil washes at less than a month before or after sulphur spraying.

Mineral and vegetable oil emulsions are used as a convenient vehicle for pyrethrum extract and rotenone, and experiments indicate that the presence of the oil increases the toxicity of the contact action.

(*e*) *Derris.* Derris washes are comparatively non-poisonous to warm-blooded animals and have a greater range of toxicity to insect pests than nicotine and lead arsenate. Provided that they are in a suitable form and concentration a good measure of control of aphid, red spider, capsids, apple sawfly and small winter moth larvae may be obtained. Commercial experience with derris as a means of controlling apple pests in this country is limited and the results have been variable. The indifferent results are probably due to the use of too low a concentration of the toxic principle (rotenone). Derris is used mainly in two forms for the preparation of washes, (*a*) finely ground derris root added to a weak soap solution, and (*b*) an oil emulsion consisting of a derris extract in a mineral or vegetable oil.

The duration of effective toxicity after application of some preparations may be several days, but critical data on this point are not available for apple pests. Derris dusts have not been used to any extent on apples.

(*f*) *Pyrethrum.* The most satisfactory pyrethrum preparations are in the form of emulsions and, provided the content of toxic principles (the pyrethrins) in the wash is sufficiently high, a good control of aphides, red spider, capsids, apply sawfly and the larvae of the winter moths may be obtained. The high price of the washes renders them too expensive for commercial plantations, but they are well suited for application to apples in market gardens with undercrops, on account of their harmlessness to foliage and non-poisonous properties to man.

(*g*) *Lime sulphur.* The commercial lime sulphur concentrates in general use contain 24—25 per cent. (weight in volume) of sulphur in polysulphide form, *i.e.* a wash made from a gallon of the concentrate will deposit on drying approximately $2\frac{1}{2}$ lb. of finely-divided sulphur. The film of sulphur left when a lime sulphur spray dries consists of very minute particles and is remarkably rain-resistant. Lime sulphur thus forms an excellent protective, while the freshly prepared wash is also effective as a contact spray by virtue of its polysulphide content.

A programme of two pre-blossom applications of lime sulphur at 1 in 30 strength followed by one post-blossom spray at 1 in 60 gives a high measure of scab control. This programme, in addition, arrests apple mildew attacks and helps to check red spider, although it is insufficient to control heavy attacks of this pest.

Serious damage to certain apple varieties may result from lime sulphur applications subsequent to blossoming. After the flowering period, it is dangerous to give Stirling, Lane or Newton any sulphur spraying; for Cox, the lime sulphur spray should not be stronger than 1 in 100 and for Bramley, not stronger than 1 in 80. The other varieties listed in Section A may be sprayed post-blossom with lime sulphur at 1 in 60 strength.

(*h*) *Certain other forms of sulphur.* The sulphur suspensions marketed under the style of "colloidal sulphurs" contain from 40 to 60 per cent. of sulphur by weight. The particles left on the drying of a colloidal sulphur spray are approximately as fine as those deposited on the drying of a lime sulphur wash, but the dilutions at which these sprays are applied (usually 5 lb. colloidal sulphur to 100 gallons) render the deposit of sulphur on the sprayed trees exceedingly tenuous.

The sulphur dusts consist usually of at least 90 per cent. of finely-divided sulphur. They possess the advantage of great convenience in application, provided that this is carried out during a period of low wind velocity. The outstanding de-merit of dust applications is that the deposit is very little resistant to rain, so that the protection afforded by dusting is not lasting in stormy weather. In general it may be said that, for scab control, dusts and the colloidal sulphurs are often useful adjuncts but that neither is at present an effective substitute for lime sulphur.

(*k*) *Bordeaux Mixture.* For combined cheapness and efficiency in the control of scab, home-made Bordeaux mixture remains unrivalled, but it gives no help in the control of mildew and red spider. Furthermore, it is more damaging than lime sulphur, since as a post-blossom spray it causes russetting of Beauty of Bath, Cox, Grieve, Lane, Stirling and Worcester. Russetting of Cox also results from Bordeaux spraying at the pink stage. These drawbacks place severe restrictions on the use of Bordeaux mixture in the spraying programme.

3. List of Spray Applications Commonly Required.

In summing up the list of separate insecticidal and fungicidal sprays in general use, an instance will be taken of a plantation (*e.g.* Worcester Pearmain) in which winter washing with a standard

tar distillate has been carried out. It is assumed that in addition to red spider eggs, living eggs of apple capsid remain after the spraying, and that sufficient live aphid and caterpillar eggs remain to make a " clearing-up " summer wash necessary. The following list shows the full range of possible sprayings from which a programme could be chosen :—

At swelling stage	..	Petroleum (5 to 7½ per cent.) for eggs of apple capsid and red spider.
At green-flower stage	..	Lime sulphur 1 in 30 for scab. Nicotine 8 oz. to 100 gall. for aphid.
At pink stage	.. ..	Lime sulphur 1 in 30 for scab. Nicotine 10 oz. to 100 gall. for aphid and capsid. Oil 2 per cent. for red spider. Arsenate paste 4 lb. to 100 gall. for caterpillars.
At petal-fall stage	..	Lime sulphur 1 in 60 for scab. Nicotine 10 oz. to 100 gall. for capsids and sawfly. Oil 1½—2 per cent. for red spider. Arsenate paste 4 lb. to 100 gall. for caterpillars.

It is seen that there is the opportunity of controlling all the pests by applications at two periods only, pink stage and petal-fall, provided that all the applications could be made in the time available. This obviously calls for the combination of sprays, but in the above list the only pair of spray applications that could be selected as a combination in general use would be lime sulphur and arsenate. Other insecticide-fungicide combinations which have been in use for many years are Bordeaux-arsenate, sulphur-arsenate dusts and sulphur-nicotine dusts. It is easily seen, however, that the increase in red spider, sawfly and capsid infestation has raised a problem which these older combinations do little to solve.

C.—THE DEVELOPMENT OF NEW COMBINED SPRAYS.

1. Literature on New Combinations Recently Suggested.

In this country, much recent work on new combined sprays for apples has been carried out by Martin and his colleagues. This author (1932) describes a method of combining a copper fungicide and nicotine by emulsifying an oil solution of the insecticide with Bordeaux mixture. It was shown that the adhesiveness of the Bordeaux deposit was greatly increased by the presence of the oil. In the same year, Austin, Jary and Martin record preliminary trials with a Bordeaux-cotton seed oil-nicotine spray and a Bordeaux-sulphite lye-nicotine mixture. These washes applied to the apple

varieties Grenadier, Early Victoria and Newton on June 8th reduced sawfly attack without causing foliage damage. Salmon and Ware (1933) report that a Bordeaux-oil spray spray (4 lb. copper sulphate, 6 lb. hydrated lime, $\frac{3}{4}$ gall. cotton-seed oil, 100 gall. water) gave satisfactory control of scab on four varieties of pears without causing spray damage.

In U.S.A. and in Australia both Bordeaux-oil emulsions and lime sulphur-oil emulsions appear to be in general use, and there is an extensive literature dealing mainly with methods of mixing and liability to foliage injury. For example, Yothers and Winston (1924) describe methods of mixing emulsified mineral lubricating oils with lime sulphur or hard water using stabilisers such as glue or casein. Much of the work relating to leaf injury has been carried out on citrus in California and the results reported are very conflicting. The majority opinion appears to be that a combined oil-lime sulphur spray is not safe on foliage after the delayed dormant stage in the case of apples.

2. Experimental Work at Long Ashton.

(*a*) *Objects of investigation.*

Section B (3) of this paper leads to the conclusion that the need for combined washes is most acute at the pink and petal-fall stages, when applications of some or all of the following types of spray are required simultaneously —fungicide, oil emulsion, contact wash and stomach poison. On the considerations stated in Section B (2) the most generally desirable representatives of these spray types are deemed to be lime sulphur, white oil, nicotine and arsenate respectively. Taking also into account the requirements of stability and safety on foliage, the aim of the investigation can be stated as *the production of an emulsion of white oil to which could be added either lime sulphur or nicotine or arsenate, singly or jointly, to form a concentrate miscible with hard water to give a stable spray not damaging to foliage.*

The progress made towards this objective is reported in the remainder of this paper.

(*b*) *Laboratory Experiments* 1932–33.

(i) *Oil-Lime Sulphur Mixtures.* From a chemical standpoint, the preparation of an oil emulsion miscible with lime sulphur or hard water, or both, is the problem of preparing an emulsion which remains stable in the presence of a comparatively large concentration of calcium and magnesium salts. This limits considerably the choice of an emulsifying agent, since ordinary soaps and sulphonated castor oil soaps when mixed with calcium salts all give

compounds relatively insoluble in water. Further, these compounds are frequently partially soluble in oil and are for this reason liable to produce water-in-oil emulsions useless for spraying purposes.

The search for suitable emulsifying agents has included the following substances :—

1. Turkey Red Oil and Glue.
2. Glue.
3. Calcium Caseinate.
4. Casein.
5. Casein and Glue.
6. "Penetrol" and Casein.
7. Agral S.R.
8. Agral S.R. and Glue.
9. Agral S.R. and Casein.
10. Agral S.R.T.
11. Sulphite Liquor.

The oil used throughout was Shell P_2.

Small quantities of the emulsions were prepared with the aid of a Pentecrème Cream-making Machine, and larger quantities, where necessary, with an emulsion mill.

As far as the present investigation has gone, only sulphite liquor and Agral S.R.T. of the above materials appear likely to be satisfactory. The emulsions prepared with the aid of casein contained oil globules which were relatively large, and these coalesce to give rise to free oil in the emulsion concentrate. Possibly a different type of emulsifying machine might give a better dispersion of the oil. Emulsions prepared with the aid of "Penetrol" only appeared to be stable towards lime sulphur in the presence of large quantities of casein or glue. Owing to the variation in the physical properties of casein with its mode of preparation and age, some sort of specification will have to be made before casein can be recommended. Glue also is of a very variable nature, and the samples so far used either alone or in conjunction with casein, have not been at all satisfactory.

Sulphonated castor oil which had not been treated with alkali, on the addition of glue, gave emulsions which were more stable than those prepared with the addition of glue to ordinary Turkey Red Oil, *i.e.* sulphonated castor oil that has been treated with alkali. The former emulsions were comparatively stable when mixed with lime sulphur diluted with distilled water, but when diluted with hard water the oil was immediately thrown out as a white curd.

Agral S.R. does not give insoluble salts with calcium, but in the presence of large quantities of this ion there is a strong tendency to produce water-in-oil emulsions, and this tendency is accentuated

by the presence of magnesium. This instability, however, can be decreased by the addition of glue or casein or by the use of a greater percentage of the emulsifier. When the concentration of the emulsifier is above 12 per cent. of the oil content, the emulsions are quite stable in the presence of lime sulphur. Agral S.R. has the disadvantage of producing emulsion concentrates which are extremely stiff and therefore difficult to dilute. Further, as lime sulphur is slightly alkaline and Agral S.R. slightly acid, some precipitation of sulphur occurs when lime sulphur is added to the dilute emulsion.

Sulphite liquor—a waste product in the production of wood pulp—gave emulsions which were stable towards lime sulphur and hard waters. It emulsifies the oil quite easily if the first addition of oil to the emulsifier is not too great. The resulting emulsion, containing 65-75 per cent. of oil, 5 per cent. sulphite liquor and 20-30 per cent. water, does not set to a stiff jelly and is easily diluted with water. On standing, a dilute emulsion containing 5 per cent. of oil creams only very slowly, and can easily be converted to its original condition by shaking.

If Agral S.R.T. is used as the emulsifier, any cream formed in these circumstances cannot be dispersed. Agral S.R.T. has also the disadvantage at present of being considerably more expensive than sulphite lye.

(ii) *Addition of Nicotine.* The chief essentials in the preparation of a nicotine spray are alkalinity and the presence of a good wetting agent. The mixed wash will be alkaline both on account of the lime sulphur present and on account of the excess lime that it will probably be necessary to add to prevent the formation of soluble arsenic (see below). The wetting power of the wash will be supplied in part at least if not completely by the emulsifying agent present.

(iii) *Addition of an Arsenical.* The experiments relating to the incorporation of an arsenical compound are still incomplete. The form of arsenical usually employed—lead arsenate—is chemically incompatible with lime sulphur, but in actual practice a lead arsenate which is not very finely ground soon ceases to react with lime sulphur because the individual particles probably become coated with black lead sulphide. A finely-divided sample of lead arsenate, however, when mixed with dilute lime sulphur is very largely converted into lead sulphide, while the proportion of water-soluble arsenic is increased.

As lead arsenate, in addition, is acid, and lime sulphur is slightly alkaline, experiments are in hand using basic calcium arsenate as an alternative. Robinson (1918) and Goodwin and Martin (1926)

have shown that the addition of lime to the spray fluid renders calcium arsenate practically insoluble until the lime is carbonated. In the absence of excess lime, severe spray damage may occur. Experiments have been carried out to determine the extent to which the solubility of calcium arsenate is affected by the other constituents of the mixed wash. In the presence of excess lime in the mixed wash there appears to be only traces of soluble arsenic. At present, therefore, we may assume that when this form of arsenical is used in the mixed wash, the addition of lime should greatly reduce the risk of foliage damage.

(*c*) *Field Trials* 1932–33.

For the 1932 season, no completed mixed wash was available and the experiments were carried out with two washes, one including oil, lime sulphur and (in part) nicotine ; the other combining lime sulphur with nicotine. The oil-lime sulphur combination was effected with the use of Agral S.R., a material with certain drawbacks as pointed out in the previous section. For these reasons the experiments recorded below are to be considered merely as indications of the lines along which further trials will be carried out.

(i) *Oil-Lime Sulphur Sprays.* On April 29th, 1932, nine gallons of Shell P2 were emulsified with Agral S.R. at Long Ashton, and on May 6th this emulsion was diluted to 2 per cent. strength and sufficient lime sulphur was added to make a 3 per cent. lime sulphur spray. This combined wash was applied with a power sprayer and guns to 96 trees of Bramley, 96 of Lane and 12 of Worcester, the total spray fluid being 320 gallons. These trees had not been winter washed and were badly infested with aphid and red spider. At the time of spraying, the Lanes and Worcesters were in the green flower stage, the Bramleys mid-way between green flower and pink. A week later, slight scorching of the leaf margins was noted on all the sprayed trees, but the damage was at no time serious.

On May 9th it was noted that while a kill of many aphides and of young Tortrix and Winter Moth larvae had been secured, there were still live aphides present at the base of the flower stalks. A count was carried out on May 19th, comparing twelve trees of Worcester sprayed on May 6th with the oil-lime sulphur mixture with twelve adjoining trees sprayed on May 4th with lime sulphur alone. In making the count, 50 buds were selected at random on

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each tree and the number of these obviously infested with aphides was recorded, the figures being :—

Sprayed with oil + lime sulphur.	Sprayed with lime sulphur.
13	10
14	20
12	11
2	13
7	24
6	25
9	16
19	37
11	28
18	27
21	13
15	24
Total .. 137	248

The figures suggest some check to the aphides following the use of the oil, but by no means a satisfactory control. The development of red spider was noted as much slighter on the oil-sprayed trees than on corresponding trees with the foliage not oil-sprayed, but no counts were carried out.

A more detailed experiment was made in Worcestershire on 24 seven-year-old trees of Worcester Pearmain. This block had been winter-washed and was lightly infested with capsid. Certain of the trees were sprayed in three stages with an oil-lime sulphur spray at the following strengths :—

At green-flower stage (May 6th) .. 5 per cent. oil with 3 per cent. lime sulphur.
At late pink stage (May 24th) .. 2 per cent. oil with 3 per cent. lime sulphur.
At petal-fall stage (June 9th) .. 2 per cent. oil with 1½ per cent. lime sulphur.

At each stage, control trees were sprayed with oil alone or lime sulphur alone, the experiment being planned to give every permutation of the individual and combined spray treatments.

In carrying out the programme the washes were diluted with very hard water (total hardness 36.6°), and this, with the deterioration of the emulsions on keeping, resulted in the presence of free oil in the spray fluid. At the second mixing (May 24th) in particular, free oil and "scum" (resulting from reaction with the container) were evident, the material used having been previously stored for a month.

A count on the fruit was made on July 6th, but the crop was too scanty to make it possible to draw conclusions concerning capsid control. Observations on spray damage showed that a slight scorching followed each application but, throughout the experiment, the damage resulting was transient and of no serious importance.

It is noteworthy that weather conditions in the spring of 1932 were by no means inimical to spray damage, since injury from lime sulphur spraying at this time was recorded from many localities in the Bristol Province.

In 1933, a series of trials was carried out in the Long Ashton plantations on a block of trees 12 years planted, the varieties included being Allington, Beauty of Bath, Bramley, Cox, Grenadier, King of the Pippins, Lane, Newton, Ross and Worcester. Trees of all these varieties were included in each spray treatment, with the exception of the post-blossom spraying.

The first spraying was made on 30 trees on April 7th when the blossom buds were round about the green flower stage. The spray used was 3 per cent. lime sulphur combined with 5 per cent. P2 oil which had been emulsified with sulphite lye. A total of 40 gallons was applied in warm sunny weather using a 9 h.p. outfit and spray guns. By April 20th it was noted that slight scorch was present on the leaves of Beauty of Bath and Newton, and very slight scorch on the leaves of Cox. There was no other damage, and it may be noted that the trees of Allington, Beauty of Bath and Grenadier had had a 3 per cent. lime sulphur spray only three days before the oil-lime sulphur spraying.

The next application, at the pink stage, was carried out on 235 trees in the same plot (including the 30 mentioned above) on April 21st. The spray used was 2 per cent. P2 oil emulsified as before and combined with 3 per cent. lime sulphur. A total of 385 gallons was applied in cool, cloudy weather. A wet period followed on the 23rd and 24th, but the spray deposit withstood the rain satisfactorily. No damage was recorded following this application.

In the post-blossom spraying the trees of Lane, Newton and Cox, being sulphur-sensitive, were omitted when any sulphur-containing sprays were applied. Three types of treatment were carried out after the blossoming stage. One block of 85 trees was sprayed with 130 gallons of oil emulsion (1½ per cent. P2) on May 19th, followed on May 30th by a 1½ per cent. lime sulphur spray. On the latter date another block of 70 trees was sprayed with 150 gallons of a mixed wash consisting of 1½ per cent. emulsified P2 oil and 1½ per cent. lime sulphur. Lastly a block of 28 trees was sprayed with 70 gallons of an " omnibus " wash, which included. per 100 gallons of wash, 1½ gallon of P2 oil (emulsified as before), 1½ gallons lime sulphur, 3 oz. nicotine, 2 lb. calcium arsenate and 3 lb. of lime. These washes were all mixed and applied without trouble and adhered well to the foliage. A period of very hot weather followed, during which a little defoliation occurred on the trees treated with lime

sulphur only. The defoliation was accentuated on the plots sprayed with oil-lime sulphur and with oil-lime sulphur-arsenate, but was nowhere marked except on the trees of Allington, Ross and Bramley, which had been sprayed with the arsenate-containing wash. The crop on the sprayed trees, however, was not adversely affected in the fortnight following the applications, but until more extensive tests have been carried out, it is clear that the advisability of incorporating an arsenical in the mixed wash must remain in question.

(ii) *Lime Sulphur-Nicotine Sprays.* A preliminary trial was carried out with mixed sprays designed to combine the post-blossom scab spray with the nicotine application against apple sawfly. Two sprays were made up containing wetting agents more effective than soap and compatible with lime sulphur. The formulae were as follows :—

Spray A.	Lime sulphur	1½ gall.	per 100 gall. water.
	Nicotine	8 oz.	
	Agral I	2½ lb.	
Spray B.	Lime sulphur	1½ gall.	per 100 gall. water.
	Nicotine	8 oz.	
	Lethalate wetting Preparation No. 1. ..	1 lb.	

Nine trees of Worcester Pearmain at Long Ashton were sprayed on June 7th, 1932, with 20 gallons of Spray A and nine others were sprayed with 20 gallons of Spray B. Both sprayings were carried out with a power sprayer and guns. Six trees were left as a control.

Counts of sawfly attack were made on July 5th and resulted as follows :—

	Total Fruits.	Sawfly Fruits.	Per cent. Sawfly.
Unsprayed	3101	2480	80
Sprayed L.S.-Nicotine-Agral. ..	4921	2287	46
Sprayed L.S.-Nicotine-Lethalate ..	4118	1426	35

No spray damage was recorded on any of these trees, and the scab control obtained was not inferior to that on comparable trees sprayed with the lime sulphur alone.

Summary.

1. A review of the present spraying programme on apples suggests the need for a combined wash incorporating a fungicide, an oil emulsion, a contact insecticide and a stomach poison.

2. The preparation of a practicable spray fluid combining lime sulphur, oil emulsion and nicotine is described.

3. Field trials with an oil-lime sulphur mixture applied up to the petal-fall stage on Worcester Pearmain showed no serious foliage damage. A small trial of lime sulphur plus nicotine and a wetting agent, applied on Worcester at the petal-fall stage for the simultaneous control of scab and sawfly, gave promising results.

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TRIALS WITH A "COLLOIDAL" COPPER SPRAY FLUID.

By R. W. Marsh.

I.—On Apples.

Scab control on the varieties Stirling Castle and Lane's Prince Albert presents a difficult problem in that these varieties cannot safely be sprayed in the summer with either lime-sulphur or Bordeaux mixture. After the blossoming period, the application of lime-sulphur to Stirling or Lane causes heavy fruit drop while, in the same circumstances, Bordeaux spraying leads to serious russetting. It was pointed out in Long Ashton Report 1928 (p. 120) that the substitution of colloidal sulphur for lime-sulphur did not provide a solution of the problem, and in the Report for 1930 (p. 155) it was shown that the addition of aluminium sulphate to a lime-sulphur spray would not obviate this type of damage. Preliminary trials carried out in 1931 suggested that a commercial "colloidal" copper spray (Bouisol) might be safely used for post-blossom application on Lane's Prince Albert. Further experiments on this variety and on Stirling Castle with Bouisol are given below.

(*a*) *Stirling Castle.* A block of 35 trees of Stirling Castle, 14 years planted, was sprayed at Long Ashton on May 3rd, 1932, with Bouisol* at the strength of 3 pints to 100 gallons. The blossom buds were then halfway between the green flower and the pink stage. Spraying was done with a 4 h.p. outfit and guns, a total of 40 gallons being applied. Weather conditions were favourable and the spray dried on well. The remaining 37 trees of Stirling Castle in the plot were left as a control.

A post-blossom application on the same trees, using Bouisol at $1\frac{1}{2}$ pints to 100 gallons, was made on June 16th. In all, 50 gallons of spray were applied, using the same outfit as before. Spraying conditions were good, and generally fine dry weather was experienced in the succeeding two months. Up to the end of June, no damage resulting from this spraying was seen, but by July 5th russetting was obvious on the sprayed fruits while absent from the controls. The crop was picked on August 23rd when it was noted

* The product distributed in 1932, containing 12.5% copper.

that the Bouisol-sprayed fruit showed a diffused, reticulate russetting chiefly towards the eye. Both sprayed and unsprayed fruits showed slight russetting at the stem end. The additional russetting on the sprayed crop was sufficient to lower the value of the fruit. As the amount of scab on the controls was very small, no attempt to assess the fungicidal value of the spray treatments was made in this instance.

(*b*) *Lane's Prince Albert.* A small trial was carried out at Long Ashton on nine trees of Lane's Prince Albert, 18 years planted. Six of these trees were left as controls; the remaining three were sprayed with Bouisol at 3 pints to 100 gallons on May 14th and again with Bouisol at 1½ pints to 100 gallons on June 16th. Both sprayings were carried out with a hand-operated bucket pump. No damage to the fruit resulted from this spray treatment and the crop was entirely free from russetting when picked on August 23rd. A count was made at the same date, the fruits being sorted into categories as follows :—

	Sprayed Trees.	*Total.*	*Percentage.*
I.	Fruits entirely free from scab	29	33%
II.	Fruits with total scabbed area less than ¼″ square..	34	38%
III.	Fruits with total scabbed area ¼″—½″ square ..	25	28%
IV.	Fruits with total scabbed area more than ½″ square	1	1%
	Unsprayed Trees.		
I.	Fruits entirely free from scab	15	8%
II.	Fruits with total scabbed area less than ¼″ square..	40	22%
III.	Fruits with total scabbed area ¼″—½″ square ..	108	60%
IV.	Fruits with total scabbed area more than ½″ square	18	10%

The scab counts showed a marked beneficial effect following the use of Bouisol, the clean and lightly scabbed fruits (categories I and II) making up 71% on the sprayed trees as against 30% on the controls. At the same time, the absolute standard of control obtained with this programme of spraying was not high, suggesting that while Bouisol may safely be used to provide a post-blossom spray for Lanes, a better protection is required in the pre-blossom stage.

II.—On Black Currants.

The routine spraying at Long Ashton against Black Currant Leaf Spot is Bordeaux mixture 2–4–50 directly after cropping, which gives generally satisfactory control. Requests have, however, been received for a spray treatment which could be applied before the crop was picked. Bordeaux mixture applied in May

and June, although giving fair control of the disease, cannot be recommended, since the residue left on the fruit from this spraying renders it almost unsaleable. Since the spray deposit left by Bouisol on drying is almost imperceptible a trial of this substance was made in 1932 as a pre-cropping spray. In the same season it was also compared after cropping with the standard Bordeaux treatment.

The trials were carried out on a block of 184 black currants planted in the winter of 1930–31 and thus cropping for the first time in 1932. The block was made up as follows :—68 bushes of French, 96 of Baldwin, 19 of Raven and 1 of Boskoop. The spraying trial was laid out so as to include bushes of French and of Baldwin in each treatment.

On June 14th, 54 bushes were sprayed with Bouisol at $1\frac{1}{2}$ pints to 100 gallons, using a knapsack sprayer. A total of 10 gallons of spray was applied in favourable spraying weather.

The crop from all the plots was picked on July 25th, by which date there was no visible residue on the Bouisol-sprayed berries.

On July 30th, 45 other bushes were sprayed with Bordeaux 2–4–50 and another 33 with Bouisol at $1\frac{1}{2}$ pints to 100 gallons. All sprayings were carried out with a headland sprayer and gun in dry but windy weather. Ten gallons of Bordeaux were used and the same quantity of the Bouisol spray.

Results were judged on September 28th, the amount of foliage remaining on the bushes being assessed by eye, each bush being allotted a mark ranging from 0 to 10. Thus a bush completely defoliated would receive 0 ; a bush half defoliated 5, etc. The average figure for all the bushes of one variety receiving a treatment was then multiplied by ten to give a percentage of foliage retention, indicating the effectiveness of the spray treatment.

Results were taken only on the bushes of French (relatively resistant to leaf-spot) and Baldwin (susceptible).

Results on French.	*Per cent. foliage retained.*
No spray (11 bushes)	45%
Post-crop Bouisol (10 bushes)	72%
Post-crop Bordeaux (19 bushes)	75%
Pre-crop Bouisol (28 bushes)	55%
Results on Baldwin.	
No spray (16 bushes)	29%
Post-crop Bouisol (19 bushes)	45%
Post-crop Bordeaux (21 bushes)	48%
Pre-crop Bouisol (20 bushes)	32%

The results on both varieties agree in showing that the Bouisol spray applied after cropping is approximately as effective as the Bordeaux spray applied at the same time. The pre-cropping Bouisol spray has little effect by the end of September, but, in view of the fact that it leaves no observable residue on the berries, it may prove of some value if used as an adjunct to the standard post-cropping application. Until further investigations have been carried cut, however, it is not possible to give an opinion on the desirability of a pre-cropping spray when the berries are being grown for canning.

FURTHER OBSERVATIONS ON THE CONTROL OF THE APPLE SAWFLY

HOPLOCAMPA TESTUDINEA. (KLUG.)

By H. G. H. Kearns and T. Swarbrick.

Introduction.

In experiments at Long Ashton (1) in 1931 on the variety Worcester Pearmain, a high control of the Apple Sawfly was obtained by the application of a nicotine wash at a period of 3—8 days after petal fall, whilst a poor control resulted when the wash was applied after an interval of 12 days. It was evident from the results that the vulnerable period in that particular season and plantation was limited to a period of less than 12 days after petal fall. By examination it was determined that the nicotine wash used had provided a control by killing recently hatched larvae and larvae just about to emerge from the eggs. In view of the fact that approximately the same measure of control was obtained by applications of the same wash made at 3, 4, 5, 6, 7 and 8 days after petal fall, it would appear that the majority of the larvae must have been subject to the effective toxic action of the nicotine wash applied at any time within this particular period. During this time the larvae are either within the calyx cup or just commencing to burrow beneath the calyx, and it is at this stage that they are killed by a penetrating contact wash.

In 1932, further experiments were conducted at Long Ashton to determine whether the spray dates previously determined were correct for a second season, and to ascertain the degree of control obtained by the use of washes containing several different toxic substances.

Lay-Out of the Experiment.

The same trees of the Worcester Pearmain variety were used and divided into similar groups as in the previous season. They comprise a block of ninety-six eleven-year-old trees on one of the Rootstock Plots at Long Ashton. The trees are planted in twelve groups of eight in successive rows, the eight trees in each case being upon a uniform rootstock. Eight groups of twelve trees were taken *across* the plot so as to provide one tree upon each of the

twelve rootstocks in each group. Thus the groups were comparable. The same group was left as an unsprayed control as in 1931, and the remaining seven groups were sprayed at definite intervals of time after petal fall with the washes described below.

The Washes and their Application.

Nicotine Wash. A wash similar to that used last season was applied. The composition was as follows :—

8 fl. oz. Nicotine (98 per cent. purity).
2½ lbs. Agral I. (Activator and Spreader).
100 gallons Water.

This wash has excellent spreading properties due to the presence of the Agral I. The toxic action is by contact and the duration of effective toxicity in hot weather is not greater than a few hours after application.

Pyrethrum Emulsion. A one-solution proprietary product consisting of pyrethrum extract and an emulsifier was employed. It was applied at a concentration representing 0.5 per cent. of good quality pyrethrum flowers. The emulsion possessed excellent spreading properties and the fruitlets were thoroughly wetted. This wash killed all exposed young larvae.

Derris Soap Solution. The wash consisted of :—

2½ lbs. finely ground derris root.
10 lbs. soft soap.
100 gallons water.

The concentration of rotenone was 0.004 per cent., which was sufficient to kill the young larvae provided it came into intimate contact with them. The wash possessed good spreading properties.

Derris Emulsion. A proprietary wash which consisted of a derris extract in a rape oil emulsion and was applied at a concentration representing approximately 1.0 per cent. of the rape oil and an undetermined content of rotenone. The emulsion wetted the fruitlets thoroughly.

Colloidal Lead Arsenate. The lead arsenate was in an extremely finely divided condition, and it remained in suspension in the water for a considerable length of time. It was applied at the rate of 4 lbs. per 100 gallons of water to which 2½ lbs. of Agral I. had been added in order to aid the distribution of the wash. An examination of the fruitlets after spraying showed that the arsenate was present in most of the calyx cups. The arsenate is a stomach poison, and

thus any control obtained was due to the larvae feeding on the tissues of the calyx which had been covered by particles of the poison.

The spray applications were made at determined intervals of days after petal fall which, for the present purpose, is defined as the period when the majority of the petals fell when the branches were subjected to a sharp vibration by tapping upon them. Spraying was carried out when the trees were dry, and each tree required about $1\frac{1}{2}$ gallons to wet thoroughly all the fruitlets. A $3\frac{1}{2}$ h.p. spraying outfit was used. and a thorough application of each wash was made. None of the washes used caused any scorching of the foliage.

The sprays were applied to separate groups of trees at the following periods after petal fall :—

Group No.	*Wash.*	*Days after Petal Fall.*
1	Nicotine	6 days.
3	,,	7 ,,
7	,,	12 ,,
2	Colloidal Lead Arsenate	7 ,,
4	Pyrethrum	7 ,,
5	Derris Emulsion	7 ,,
6	Derris Soap	7 ,,
8	Untreated Control	

Results of the Experiment.

The results of the experiment are given in Table I, which is presented in the same form as that used in 1931. The number of fruits "set" upon each tree was determined about fourteen days after petal fall. In mid-July, when all the larvae had emerged from the infested fruits, the trees were carefully picked over and all the infested apples, including those which had already fallen to the ground, were collected and counted. The results are shown in the table in such a manner that the variation from tree to tree may be observed.

It is evident that a high control was obtained with the nicotine wash applied at the 6th, 7th and 12th day after petal fall, reducing the infestation from 41.0 per cent. to 10.6 per cent. or less. This confirms last year's results that the wash may be applied within a period of 6—7 days after petal fall with approximately equally good results. In 1931 the application at 12 days after petal fall did not give a satisfactory control, since it only reduced the infestation from 54.8 per cent. to 34.6 per cent., whereas in 1932 a similarly

timed application gave a highly satisfactory control, reducing the attack from 41.0 per cent. to 10.6 per cent. This indicates that the latest period for an effective application on the same trees varies from season to season. Moreover, it has been observed at various localities in the Bristol Province that variations in the length of the egg laying period, the incubative period of the eggs and the length of time which elapses between full bloom and petal fall in the case of Worcester Pearmain and other varieties occur which render it difficult to determine the optimum period for applying a wash in order to obtain the most satisfactory results from *one* application of an efficient contact insecticide.

The result obtained with the colloidal lead arsenate—which reduced the infestation from 41.0 per cent. to 19.8 per cent.—shows that the larvae consume some of the surface tissues of the calyx area during their feeding before they commence to burrow into the fruitlet. The control obtained by a lead arsenate wash (4 lbs per 100 gallons) was approximately half that obtained with the nicotine wash (8 ozs. per 100 gallons) applied on the same day. The difference is possibly explained by the fact that at the time the wash was applied a number of the larvae had already commenced to burrow and therefore could not consume any poisoned tissues, whereas the nicotine wash, in addition to being toxic to exposed larvae, was toxic to the larvae in surface burrows.

The results obtained with the pyrethrum emulsion and the derris soap may be similary explained since their toxic properties depend on their coming into intimate contact with the *exposed* larvae, whilst they cannot kill larvae in the burrows.

The derris emulsion, which is a suspension of derris root in an emulsion of rape oil, reduced the infestation to 9.2 per cent., and it possibly owes its increased efficacy, as compared to the derris soap, mainly to the ease with which it penetrates into the larval burrow owing to the presence of the oil. It is interesting to note that the derris soap wash was superior to the derris emulsion for the control of the larvae of the Loganberry Beetle (2).

Summary.

1. In 1932 a further trial was carried out on the control of the Apple Sawfly larvae on the variety Worcester Pearmain. The same group of trees was used for the experiment as in 1931 in order to determine if the satisfactory results obtained in that year with a nicotine wash could be repeated. Other insecticides were also tested under comparable conditions.

2. An efficient control was obtained by spraying the fruitlets

with a nicotine wash (using 8 ozs. to 100 gallons water plus a suitable spreader) between the 6th and 12th days after petal fall. The results confirmed those of 1931 except that in that season the application of the wash at 12 days after petal fall gave a poor control. The difference is probably due to a more protracted egg laying period in 1932.

3. A derris rape oil emulsion provided a result equal to that obtained with a nicotine wash applied at the same date and period after petal fall. A derris soap wash (representing a concentration of 0.004 per cent. rotenone) provided a fairly satisfactory control, but not equal to that obtained with the derris emulsion or with nicotine.

4. A colloidal lead arsenate wash and a pyrethrum emulsion (representing a concentration of 0.5 per cent. of the flowers) each reduced the infestation by 50 per cent.

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TABLE I

Showing the Control of Apple Sawfly Larvae obtained by the Application of Spe

Variety: WORCESTE

Group No. and Date of Spraying.	(1) 6/6/32			(2) 7/6/32			(3) 7/6/32			(4) 7/6/32	
No. of Days after Petal Fall.	6			7			7			7	
Insecticide Wash Used.	Nicotine.			Colloidal Lead Arsenate.			Nicotine.			Pyrethrum Em	
Rootstock.	Total No. of Fruits Set	No. of Fruits Infested	% of Fruits Infested	Total No. of Fruits Set	No. of Fruits Infested	% of Fruits Infested	Total No. of Fruits Set	No. of Fruits Infested	% of Fruits Infested	Total No. of Fruits Set	No. of Fruits Infested
t Malling— No. I	1935	78	4.0	872	157	18.0	882	33	3.7	547	98
II	1007	18	1.7	715	151	21.1	839	113	13.4	521	101
III	692	30	4.3	1102	301	27.3	756	136	17.9	446	27
IV	766	28	3.7	543	133	24.4	706	217	28.3	503	165
V	1016	13	1.2	762	133	17.4	655	45	6.8	414	104
VI	648	18	2.7	527	69	13.0	423	25	5.9	618	99
VII	310	2	0.6	394	28	7.1	489	37	7.5	293	51
IX	487	0	0	286	5	1.7	216	3	1.3	214	14
X	608	11	1.8	427	75	17.5	567	51	8.9	248	45
XII	681	24	3.5	826	151	18.2	503	42	8.3	482	88
XIII	360	9	2.5	336	104	30.9	385	23	5.9	80	3
stol No. G.8 ..	212	6	2.8	362	110	30.3	427	80	18.7	450	182
tal No. of Fruits on the Trees	8722			7150			6848			4815	
tal No. of Fruits Infested	237			1417			805			977	
erage % of Infested Fruits	2.7			19.8			11.7			20.3	

ified Insecticide Washes at Definite Intervals of Time after Petal Fall.

t PEARMAIN.

	(5) 7/6/32			(6) 7/6/32			(7) 12/6/32			(8) Control		
	7			7			12			—		
sion	Derris Emulsion			Derris Soap			Nicotine			Control		
% of Fruits Infested	Total No. of Fruits Set	No. of Fruits Infested	% of Fruits Infested	Total No. of Fruits Set	No. of Fruits Infested	% of Fruits Infested	Total No. of Fruits Set	No. of Fruits Infested	% of Fruits Infested	Total No. of Fruits Set	No. of Fruits Infested	% of Fruits Infested
17.9	509	55	10.8	758	105	13.8	608	73	12.0	679	402	59.3
19.3	593	30	5.0	822	202	24.5	1053	158	15.0	603	282	46.7
6.0	287	123	42.8	475	118	24.8	516	47	9.1	428	183	42.7
32.8	305	42	13.7	547	139	25.4	519	105	20.2	433	221	51.0
25.1	206	23	11.1	420	69	16.4	498	35	7.0	512	181	35.3
16.0	171	14	8.1	330	49	14.8	521	50	9.5	493	201	40.7
17.4	412	7	1.6	347	4	1.1	327	6	1.8	266	113	42.4
6.5	116	0	0	79	0	0	105	2	1.9	295	35	11.8
18.1	132	3	2.2	353	29	8.8	546	21	3.8	421	90	21.3
18.2	220	11	5.0	293	25	8.5	418	40	9.5	403	223	55.3
3.7	176	3	1.7	326	12	3.6	349	26	7.4	398	120	30.1
40.4	316	6	1.8	352	19	5.3	367	57	15.5	182	67	36.8
	3443			5102			5827			5113		
	317			771			620			2098		
	9.2			15.1			10.6			41.0		

*PSILA NIGRICORNIS** MEIG. AS A PEST OF CHRYSANTHEMUMS.

By H. G. H. Kearns and C. L. Walton.

The following note is written as the result of the occurrence of losses of chrysanthemum stools in the Bristol Province due to damage by the larvae of *Psila nigricornis* (closely related to the Carrot Fly, *P. rosae* Fab.). The insect is present in most nurseries and it appears under certain circumstances to increase in numbers and become a serious and established pest. In the Bath district in 1932, at one nursery, over 8,000 stools of plants grown in pots were rendered useless for the purpose of propagating cuttings. It appeared that it was the first attack that had been observed during 40 years experience of growing chrysanthemums in the locality. Yearly losses have been experienced at several nurseries around Cheltenham, although it is only recently that the cause of the injury has been recognised. Mr. J. C. F. Fryer, Director of the Plant Pathological Laboratory, Harpenden, informs us that he has records of isolated attacks occurring in another part of the country. It is probable that the pest is more widespread than is recognised at the present time.

Some Larval Characters and Nature of the Damage.

The pest may be recognised by the following brief description. The mature legless larvae are pale yellowish-white in colour and about $\frac{1}{4}''$ long. Some pupate in burrows made in the stems of the host plants, but the puparia are easily dislodged and fall to the soil; others pupate in the soil near the stem. The puparia are small, yellowish, barrel-shaped structures. Larvae obtained in February emerged as adult flies during the first three weeks in May.

The damage, which is done by the larvae (Figs. I, II), consists of (*a*) feeding on the roots, which may die for part of their length, and (*b*) the formation of a number of longitudinal burrows in the outer portion of the rootstock and first few inches of the stem above soil level. The tissues above the burrows die and dry out, and the cuticle and epidermis split leaving the burrows partly exposed as deep fissures. If the larvae are numerous, the "bark" in many

* Thanks are due to Mr. H. Britten, Manchester Museum, for the identification of the species of fly.

cases partly peels off. Extensive injury causes the death of a number of basal roots and, as a result, the stool is unable to form more than one or two, and frequently not any, "cutting" shoots. The presence of a few larvae reduces the vigour of the stool, but does not necessarily prevent the formation of a few cuttings, except in the case of those varieties which do not propagate readily. It appears, from preliminary observations, that a large number of varieties are subject to attack, but the injuries are most serious in the late varieties grown in pots. Lifted plants are much less subject to attack. It is probable that the flowering capacity of the late varieties, if severely attacked, may be reduced.

Methods of Control.

P. nigricornis is very similar in its habits to the Carrot Fly, and it is probable that the methods of control recommended for the latter may be adopted with satisfactory results. The application of suitable repellents during the oviposition period is suggested. At one nursery, which suffered severe losses in 1932, liberal applications of soot were given to each pot in August and September in anticipation of another attack. The treated stools were examined in January and they were practically free from serious injury.

The flies, apparently a second brood, may be found in early August, and it is therefore advisable to make the first application of a repellent at the beginning of the month and to repeat at intervals until about mid-October. Whizzed naphthalene is a cheap repellent and should be applied at the rate of about $\frac{1}{4}$ oz. per 10″ pot, the application being repeated as soon as the odour begins to decrease, *i.e.* at about 10 day intervals.

If a larval attack has taken place and it is detected before any serious damage has occurred (before the middle of December), the application of corrosive sublimate is worthy of trial. One ounce of corrosive sublimate (mercuric chloride) is dissolved in one gallon of hot water and diluted to 10 gallons with cold water. The solution should be watered into the pots at the rate of a half-pint per 10″ pot, and it is important that the soil is moist before the application is made in order to facilitate penetration. The mercuric chloride will kill the larvae it comes into contact with around the roots and may kill some in the stem below and just above the soil level. An application at the end of September before the larvae have done any extensive tunnelling will provide the best chances of success. It is most important to remember that corrosive sublimate is very poisonous and attacks metals; for this latter reason, it must be mixed and used in wooden or earthen vessels, or metal vessels that have been lacquered inside.

Stems of Chrysanthemum showing injury by Larvae of *Psila nigricornis*, Meig.

FIG. 1.—Stems and Rootstocks showing typical collapsed burrows and loosened epidermis. The terminal portions of the roots have been destroyed.

Stems of Chrysanthemum showing injury by Larvae of *Psila nigricornis*, Meig. FIG. 2.—Larvae and Pupae are frequently to be found in the position indicated by the arrow.

EXPERIMENTS ON THE CONTROL OF THE GREENHOUSE SYMPHYLID (*SCUTIGERELLA IMMACULATA*).

By H. G. H. Kearns and C. L. Walton.

This species of Symphylid has been recognised in the United States of America for many years as a serious pest of greenhouse and garden crops, and a comprehensive account of it is given by Filinger (1). Theobald recorded it in 1912 as occurring in Guernsey where it was responsible for considerable damage to tomatoes, etc. It was not recognised as a serious pest in England until 1928 when Walton (4) associated it with the partial and complete failures of tomato plants in several nurseries in the Bristol Province. More recently it has been detected in other parts of the country (2, 3).

The mature Symphylid is small, about 5-8 mm. long; it moves rapidly and is extremely delicate and superficially resembles a *Campodea*, but may be distinguished from the latter by the characteristic elevated manner in which it carries the cerci. Specimens required for examination are best preserved in a viscid fluid, such as Berlese Medium.

The Habits of the Pest.

The life cycle of the Symphylid in this country has not been worked out in detail, but it appears to agree approximately with the U.S.A. experience. Several overlapping generations occur during the spring and summer. The presence of the creatures in the top layers of the soil depends on a sufficiently high temperature and a suitable host plant. At the nurseries under observation tomatoes were followed by chrysanthemums grown in pots; after the removal of the latter crop just after Christmas the artificial heating was discontinued for a few weeks. This resulted in the disappearance of the Symphylids below the top layer of soil, the depth to which they penetrated depending very largely on the physical condition of the soil and subsoil. A porous, stony soil and subsoil provides the most suitable environment and numerous specimens have been found at a depth of 4-5 feet and probably occurred at greater depths.

A close textured subsoil, such as a clay or marl, limits their downward movements, and they are then confined to the soil.

Nature of the Injury.

In cases of injury to tomatoes, the plants are attacked practically at once or within a few days after setting out. The damage consists of the destruction of the root hairs, and the plant is unable to make any satisfactory growth. The full extent of the injury is made evident by the sudden flagging of the plants in a hot sun. In some cases it has been necessary to replant several times, the first plantings having failed to withstand the root injury owing to their slower growth at the earlier part of the season. In such cases planting has only been established finally later in the season when more rapid root growth occurred under better climatic conditions and careful manuring. Once the plant becomes established it is able to withstand the attack, although the crop is reduced appreciably, and on very hot days the flagging of the foliage is most noticeable.

Control Measures.

Two nurseries in the Bristol Province have been of outstanding interest in connection with the pest on account of the severity of the attacks, and the adoption of steam sterilisation as a means of control on two very different types of soil and subsoil. The growers were highly skilled and prior to the appearance of the pest had consistently produced excellent crops. The details of the occurrence of the pest and treatments given at the two centres are as follows :—

Centre I.

For some years previous to 1928, when the presence of the pest was recognised, the tomato crops had been increasingly unsatisfactory. During the next three seasons liberal applications of naphthalene were worked into the soil just before planting out as a possible means or repelling the Symphylids, but a poor control was obtained. By 1931, the pest had increased to such an extent that two plantings were ruined and the third was very poor, and in view of the fact that it was impossible to grow profitable tomato crops any longer without controlling the pest, steam sterilisation was tried as a means of control. During the autumn and winter of 1931 an excellent crop of chrysanthemums was grown, despite a large number of the pest in the pots. In January, as soon as the plants were removed, preparations were made to steam sterilise the soil thoroughly. The subsoil was a compact marl and the Symphylids were confined to the soil which was about 1½ feet deep. A trench of 15 feet length and 4 feet breadth was dug down to the

subsoil. In the trench two grids, 7 feet long by 3½ feet wide, were placed resting on the subsoil and the soil replaced and finally covered with a stout tarpaulin. Steam was then passed through the grids at 40-80 lbs. pressure for at least twenty minutes, then the grids were heaved out of the soil. In this manner the whole of the soil in the house was treated, requiring 4 men 3½ days to complete a 100 by 30 feet house.

A 17-H.P. boiler was used as a source of steam, and it was necessary to work it to the limit of its capacity to maintain a sufficient pressure. With the type of grid used the steam pressure of 80 lbs. could not be maintained for long, and at the end of 20 minutes the pressure registered about 40 lbs.

The results were excellent and a satisfactory crop was grown. The soil adjacent to some buried pipes and brickwork could not be satisfactorily sterilised and a row of plants subsequently grown in this soil were attacked. Apart from this injury no evidence of the presence of the pest could be found.

Centre II.

Experiments with a number of soil fumigants did not provide a control. In early March, 1931, a complete failure of tomato plants occurred and following this the soil was immediately steam sterilised with a harrow type grid, and a second planting made. This was free from serious injury and produced an exceptionally good crop. The tomatoes were followed by chrysanthemums grown in pots, and a satisfactory crop was produced. At the end of the season a large number of Symphylids were observed in and below the pots, and it was evident that a complete control had not been obtained earlier in the season by the steam sterilisation. The soil from the pots was taken outside the houses and treated liberally with a cresylic acid emulsion with apparently good results, as a crop of tomatoes was produced from the soil in a small greenhouse. (It has been observed that the liberal treatment of infested soils *in situ* with cresylic acid emulsion does not provide a control).

In February and early March of 1932, the soil in the houses was steam sterilised with the harrow grid and it was noted on completion that the pest had appeared in numbers from the subsoil, and the treatment was therefore repeated. Tomatoes were planted out and after a short period of excellent growth the plants suddenly showed signs of attack and large numbers of the pest were found amongst the roots. This attack was successfully checked by a heavy watering with mercuric chloride at a concentration of 1 oz. in 160 gallons water (*i.e.* 1 in 25,600). This type of treatment was

suggested by Cheshunt Experimental Station, who recommended a solution of double the concentration used in the present case.

The explanation of the variable results from the steam sterilisation treatments in the two seasons appears as follows :—

The soil contained a number of large stones and the subsoil consisted of a porous brash of a considerable depth. The Symphylids hibernated in the subsoil as soon as the temperature of the house was reduced. In the first year, when the treatment was successful, the combination of heat and the presence of a host plant attracted the majority of the Symphylids into the top layer of the soil which was effectively sterilised. In the second year of treatment, the first sterilisation probably killed very few but the heat in the houses during the treatment attracted a number of the pest from the subsoil, which could not be sterilised by normal methods on account of its great depth. The second application of the steam killed these individuals. Finally, the planting of the tomatoes attracted the remainder of the Symphylids from the subsoil.

It is evident that, when the pest occurs in a soil with a deep porous subsoil, it is impossible to sterilise to a sufficiently effective depth, and it is essential to attract the majority of the Symphylids into the top layer of the soil before steaming. The use of tomatoes as an attractant crop is much too expensive and it is suggested that cheap lettuce might suffice as it has been found that this crop is subject to injury. There is no evidence that a cheaper crop such as tares will act as an efficient attractant.

It is interesting to note that steam sterilisation in America has given unsatisfactory results.

Conclusions.

Steam sterilisation of the soil provides satisfactory results against *S. immaculata* provided the pest is within the layer of soil that can be effectively steamed.

The pest will remain in the soil when the subsoil is a clay or marl, but if the subsoil is open and porous the Symphylids will hibernate to considerable depths below the soil. In the latter case the pest must be attracted from the subsoil before steaming is commenced, and a combination of heating the houses and growing an attractant crop, such as lettuce, is suggested as a suitable means.

The number of seasons that steam sterilisation must be carried out will depend on the efficiency of the method of attracting the Symphylids into the layer of soil effectively steamed.

The boiler of the steam sterilising plant should be of ample size to maintain a pressure of 80 lbs. for 20 minutes in the grid submerged at a depth of $1\frac{1}{2}$ feet from the surface of the soil. A boiler of not less than 20 h.p. is strongly recommended when a number of large houses are treated each year.

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THE CONTROL OF HARD ROT OF STRAWBERRY FRUITS.

By L. Ogilvie.

In last year's Report reference was made to an important disease of " Paxton " strawberries which is prevalent in the Bristol Province, and to which the name " hard rot " has been given by the writer. Affected fruits have brown sunken areas with a large number of seeds which make them useless for canning purposes. The disease is caused by the fungus *Septoria Fragariae*, which also affects leaves, flower stalks and flowers. The spots on the leaves have probably been confused in many cases with those caused by *Mycosphaerella Fragariae*, the common strawberry leaf spot fungus.

In an endeavour to control the disease in a severely infected plantation, the plants were sprayed with Bordeaux mixture 5–7½–50 (made with hydrated lime) on August 22nd, 1931, and again on May 21st, 1932. Another plot was sprayed with a 5% tar oil emulsion on January 22nd, 1932.

Although the tar oil treatment killed off the leaves in January, these were succeeded by vigorous and healthy leaves and the plants in question bore a good crop.

Counts were made during the summer with the following results :

		Sepal Infection.	*Fruit Infection.*
June 17th, 1932.	Bordeaux	29%	1%
	Tar Oil	48%	7%
	Control	96%	52%

		Fruit Infection.
July 7th, 1932.	Bordeaux	25%
	Tar Oil	20%
	Control	64%

It will be seen that both the Bordeaux and the tar oil treatments give a considerable measure of control, especially in the case of the earliest part of the crop.

PROGRESS REPORT ON VEGETABLE DISEASES.—IV.

By L. Ogilvie and B. O. Mulligan.

The following report deals with work on vegetable diseases carried out in the Bristol Province, and especially in the Evesham-Pershore area, during the season 1931-32, and is a continuation of those published in previous years (8, 9, 10).

Asparagus Diseases.

Violet Root Rot of Asparagus (*Rhizoctonia Crocorum*, ? = *Helicobasidium purpureum*). Two new infected areas have been discovered, making a total of eight known infected fields. Three of the areas have been dug out and planted with non-susceptible crops. Parts of the other areas have been used for soil treatments, the following chemicals being applied, formalin, copper sulphate, cresylic acid, chloride of lime, mercuric chloride and pyroligneous acid ; certain of these areas are to be replanted with asparagus in the spring of 1933.

The fungus appears to persist in the soil in the form of peculiar pseudo-sclerotial clumps, especially prevalent in and around plants attacked for two or three seasons and then disappearing with the decay of the roots. The following common weeds of asparagus fields have been found to be infected with the fungus and to carry over infection from year to year : *Rumex obtusifolius*, *Convolvulus arvensis* and dandelion. In one field these were probably responsible for a severe attack after twelve years free from asparagus.

Pot experiments have shown that about a year is necessary for any severe infection of the roots by the fungus. Seedlings can be infected during the first year's growth, without showing signs above ground, but in a second season the attack becomes apparent by the early yellowing of the foliage about August.

Zopfia rhizophila. Plentiful material of this fungus was collected on asparagus roots on the ground previously noted. There was no evidence of any highly parasitic nature of the fungus on healthy roots. Perithecia were found only on second year or older roots, sometimes in conjunction with *Rhizoctonia*.

Pieces of old roots affected with the fungus had been added to sterile soil in pots in which seedling asparagus plants had been planted in 1930. In November, 1932, a few perithecia were found on old roots of the living plants.

The fungus has now been obtained in pure culture and further work is being done on its pathogenicity.

Diseases of Dwarf (French) Beans.

Halo Blight. Halo Blight, caused by *Bacterium Medicaginis* var. *phaseolicola*, was again prevalent in 1932, and field observations were made which confirmed those of 1931. It was again found that many of the commercial stocks of seeds were badly infected, giving rise to much field infection. In several cases early rogueing of diseased plants was practised with success. Field observations again seemed to show that badly infected seeds tended to produce fewer diseased plants when they were two or more years old.

A further variety resistance trial was laid down in 1932 at Wick, near Pershore, through the kindness of Captain C. H. Sykes. The land used had carried in 1931 a severely infected crop of the variety " Masterpiece " and, as this is one of the most susceptible varieties, it was used as a control between each trial row. The ground was ploughed after spring cabbage, in April, and the seeds of all varieties were sown on May 6th. Germination in some cases was not too good, owing to cold and wet weather, but all gaps were resown by the beginning of June. Each row was 170 yards long, and 2 feet intervals were allowed between each.

Careful records were taken of the spread of the disease from certain marked infected plants. This is shown in the accompanying table (Table I). It will be seen from Table I (Pershore area) that the large increases in infection noticed on July 12th and July 26th can be correlated with the heavy falls of rain about a fortnight before in each case, namely on June 30th and on July 16th.

(Correlation between rainfall at Evesham and spread of the disease in that district is also shown in Table II).

TABLE I.

Showing Correlation between Rainfall and Spread of Halo Blight Infection in Dwarf Bean Trials at Pershore, 1932.

(*a*) Rainfall in Inches.

June	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
	.04																		
June		..		..		20	21	22	23	24	25	26	27	28	29	30			
										.06					*.22*	*.78*			
July	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
	.04					*.14*					.06	.04	.30		.01	*.12*	.04		
July			..		20	21	22	23	24	25	26	27	28	29	30	31	Aug.	1	
							.18			*.15*	*.14*		*.12*			*.51*		*.27*	

(*b*) Infections.

		Dates of Observations.					
	June 14	21	28	July 5	12	19	26
		No of Fresh Infections.					
Affected Plants Marked on this Date.	Row 1	—	—	—	9	—	14
	,, 2	—	—	—	14	3	41
	,, 3	—	—	—	12	6	41
	,, 4	—	—	—	3	3	9
	,, 5	—	—	—	3	5	21
	,, 6	—	—	—	2	9	18
	,, 7	—	—	—	8	4	27
	,, 8	—	—	—	8	4	15
	,, 9	—	—	—	6	4	24
	,, 10	2	—	—	8	5	45
	,, 11	—	—	—	6	—	33
	,, 12	—	—	—	9	2	11
	,, 13	—	—	—	8	2	10
	,, 14	—	—	—	15	1	21
	,, 15	—	—	—	3	3	28
Totals		2	0	0	114	51	387

TABLE II.

Correlation of Rainfall and Incidence of Halo Blight at 9 Centres Near Evesham, 1932.

Rainfall at Evesham, 1932. (No rain on other dates).						Disease expected. (12 days after rain, 9-10 days at higher temperatures).
June 25th	.12 in.	..	..	..	..	
,, 27th	.04 ,,	..	..	..	..	
,, 28th	.06 ,,	..	..	..	..	
,, 29th	.15 ,,	..	..	..		July 11—13
,, 30th	.68 ,,					
July 1st	.04 ,,	..	..	..	..	
,, 6th	.10 ,,	..	..	..	..	
,, 11th	.11 ,,	..	..	..	..	
,, 13th	.25 ,,					
,, 16th	.24 ,,	..	..	..		July 25—29
,, 17th	.13 ,,					
,, 22nd	.44 ,,	..	..	..	..	August 3
,, 24th	.05 ,,	..	..	..	..	
,, 25th	.15 ,,	..	..	..	..	
,, 26th	.12 ,,	..	..	..	..	
,, 27th	.09 ,,	..	..	..	..	
,, 28th	.09 ,,	..	..	..	..	
,, 29th	.02 ,,	..	..	..	..	
,, 30th	.28 ,,					
,, 31st	.13 ,,	..	..	..		August 8—15
Aug. 1st	.32 ,,					
,, 3rd	.01 ,,	..	..	..	..	
,, 14th	.17 ,,	..	..	..	..	August 23—24

Centres.						First severe spread of Halo Blight observed.
1. Hinton (1)	..	..	..	..	..	August 3rd
2. Sedgeberrow	..	..	..	..	..	July 13th
3. Offenham	..	..	..	..	..	August 24th
4. Hinton (2)	..	..	..	..	..	August 23rd
5. Badsey	..	..	..	..	..	August 11th
6. Littleton (1)	..	..	..	..	..	August 15th
7. Hinton (3)	..	..	..	..	..	August 8th
8. Harvington	..	..	..	..	..	August 11th
9. Littleton (2)	..	..	..	..	..	August 15th

TABLE III.—Dwarf Bean Trials, 1932.

Variety.	*Date of Picking, and Crop Weights in lb.*										Order in Crop weight	Percentage Halo-Blight Infection (Leaves)			Percentage Infection of Pods.
	22nd July	29th July	2nd Aug.	5th Aug.	10th Aug.	15th Aug.	18th Aug.	24th Aug.	30th Aug.	Totals.		Clean.	Slightly Infected	Severely Infected	
1. *Black Wonder* ..	10	40	48	22	53	60	10	14	—	257	*2*	49	45	6	8
2. *Unrivalled* ..	—	2	6	18	66	32	24	40	—	241	*3*	38	44.5	17.5	16
					(11th Aug.)										
					53										
3. Satisfaction C. ..	6	1	2	12	35	49	25	42	—	172	*11*	12	60	28	18
4. The Wonder ..	—	1	24	16	50	36	15	12	—	154	*15*	13	45	42	12
5. Magpie	—	1	2	18	40	55	22	18	—	156	*14*	63	35	2	6
6. Canadian Express	6	14	32	26	45	40	24	24	—	211	*6*	8	36	56	6
7. Shah de Perse ..	—	—	4	2	22	23	36	54	50	191	*7*	5	60	35	6
8. de Lignereux ..	—	—	—	2	—	10	15	52	40	119	*17*	70	29	1	7
9. Fin de Linas ..	—	2	26	6	65	40	30	20	—	189	*8*	17	61	22	—†
10. *Abondant* ..	—	—	24	4	68	102	60	50	24	332	*1*	37.5	52	10.5	5
11. Incomparable D.	6	14	28	8	44	36	20	18	—	166	*12*	9.5	48.5	42	4
12. Incomparable B.	—	—	4	10	36	40	16	50	31	187	*9*	4	39	57	6
13. *Black Prince* ..	—	—	18	10	44	60	20	26	4	182	*10*	34	45	21	11
14. Satisfaction Y. ..	—	—	6	4	30	40	27	27	10	144	*16*	18	55	27	11
15. *Superlative* ..	—	1	8	18	50	82	20	30	8	217	*4*	52	43	5	9
16. *Ne Plus Ultra* ..	6	26	28	18	48	42	15	24	—	213	*5*	33	49	18	6
					(8th Aug.)	(11th Aug.)	(17th Aug.)								
Masterpiece (16 control rows)	96	300	520	776	610		210	Total, 2512			157*	*13*	2*	36*	62*	19

* Averages per Row.

† Not possible to make a count due to natural purple colour of pod.

The weight of the crop from each row was taken on the various picking dates. These weights are arranged in Table III to show the total weights and the amounts at each pick. This latter point serves to indicate the relative earliness or lateness of the variety.

Certain varieties (*e.g.* Nos. 5 and 8), although resistant to a marked degree, are of little or no use for the market owing to their poor crop or late season, and a combination of comparative earliness and freedom from severe infection must be sought.

The disease had a disastrous effect on "Masterpiece," this variety being severely infected over the entire plot.

From a comparison of the results of this year's trial with those of last year, it will be seen that the varieties "Black Wonder," "Ne Plus Ultra," and "Superlative" were again found to be satisfactorily resistant. To these can now be added "Abondant," "Black Prince" and "Unrivalled." "Incomparable" did not prove as resistant as in last year's trial. "Magpie" proved to be resistant, as in last year's trial, but as it does not appear to be a heavy cropper or vigorous grower, it is omitted from the list of recommended varieties. It is of interest that Labrousse (11), who has recently worked on halo blight in France, found that of thirty varieties on trial only "Abondant" proved to be resistant. The following varieties are those recommended as satisfactorily resistant to the disease and suitable market varieties for the Evesham-Pershore area :—

Abondant, Black Prince, Black Wonder, Ne Plus Ultra, Superlative and Unrivalled.

Diseases of Runner Beans.

Halo Blight. Halo Blight is found on most of the common varieties of runner beans in the Evesham area, but in this case systemic infection is uncommon and there is little check to growth. In most of the cases under observation the disease spreads from adjoining dwarf beans, but in one field seed transmission seemed to be indicated.

Wilt. In certain of the bean growing areas along the banks of the Severn we have found large patches of runner beans affected with a peculiar wilt disease. The plants become yellowish, and the leaves roll up and wither at the margins. Finally the whole plant dies off. If the bases of the stems are cut down longitudinally it is found that there is a characteristic brown discolouration of the vascular bundles. The disease is associated with a *Fusarium* sp.

Leek Diseases.

White Tip Disease. A further fungicidal trial for the control of "White tip" disease of leeks, caused by *Phytophthora Porri*, was laid down in the autumn of 1931 on a heavily infested piece of ground at Mr. H. F. Harding's, Staple Hill. The following fungicides were used: A.P.S. 1-200, copper lime dust, and Bordeaux mixture. The disease had already commenced on November 30th, when the first application was made. Further applications were made on December 22nd, January 25th and March 3rd. The trial was a failure, all the plots becoming rather severely infected with the disease. It is considered that the first application should have been made at an earlier date.

A selection of individual plants which were apparently resistant was made in 1931. Seed was saved from these and the resultant seedlings are being grown on in an infected plot of ground at the Research Station.

Basal Rot. A basal rot of leeks, associated with a *Fusarium* sp. has been found in well defined areas in fields near Evesham.

Lettuce Diseases.

Ring Spot. ("Rust.") (*Marssonina panattoniana*). Through the kindness of Mr. A. Smith a lettuce plot at Cheltenham was dusted with copper lime dust for the control of *Marssonina*, but practically no disease appeared in dusted or control plots.

A very large trial of varieties, with a view to possible resistance, was laid down in the winter of 1932-1933 on light soil near Pershore, combining also the effect of potash manuring, and copper lime dusting from an early date.

Botrytis Disease. Probably the most serious disease of lettuces in the area is the dying off of winter varieties which is often prevalent in early spring. The fungus most readily attacks the older moribund leaves and thence penetrates into the stem, causing a pinkish rot. Most of this type of stem rotting in the Bristol district is probably caused primarily by *Botrytis* and not by a bacterium resembling *B. vitians* as was at first supposed.

Botrytis cultures isolated from diseased lettuces all appear to be forms of *B. cinerea*. Characteristic symptoms were produced by the inoculation of these cultures.

A trial laid down at the Mental Hospital, Fishponds, through the kindness of Mr. J. Merrick, did not indicate any beneficial effect from an application of sulphate of potash at the rate of 3 cwt. per acre in November. Variety and other trials have been arranged for the winter of 1932-33.

Mint Diseases.

Mint Rust.

Varietal Susceptibility. The best solution of the rust problem in mint forcing would be the discovery of a mint immune to rust. This question is being explored. Through the kindness of Mr. J. Fraser we have received some plants of *Mentha cordifolia*, a hybrid mint which apparently occurs in gardens in Dorset, Devonshire, Cornwall and elsewhere. A good stock of this mint was worked up and planted alongside other mints in the Institute garden. Although the other mints became very severely affected with the uredospore stage of *Puccinia Menthae* in the summer of 1932, *Mentha cordifolia* remained entirely clean, despite attempted infection by artificial means. Forcing tests are to be made with this mint, but it seems rather doubtful whether it would be suitable for market as it remains in leaf out of doors too late in the year.

The mint in common cultivation in the Bristol Province has been identified for us by Mr. Fraser as *Mentha villoso-nervata*. There are apparently two forms of this hybrid in common cultivation, differing in leaf characters, production of flowers and susceptibility to rust. We are also investigating the rust susceptibility of other mints likely to prove useful for forcing.

Extent of Mycelium. Sections of mint plants bearing oecidia showed that the oecidial mycelium occasionally penetrated slightly into the rhizome, but not more than $\frac{1}{4}$ in. in any of the cases observed.

Treatments.

I. Through the kindness of Mr. H. J. May, of Cheltenham, the following treatments were carried out. Mint "roots" were lifted on January 15th, 1932, treated in various ways and then planted in a greenhouse in beds $5\frac{1}{2}$ ft. x $4\frac{1}{2}$ ft., there being two beds for each treatment. The results were as follows :—

Bed No.	*Treatment.*	*Total No. of Rusted Shoots.*
1.	None	46
2.	A.P.S. 1-200 (for 1 minute)	41
3.	Washed thoroughly in two changes of water	23
4.	Not washed. Sprayed with Bordeaux 4-6-40 on Feb. 16th	29
5.	Washed (as 3)	12
6.	A.P.S. (as 2)	23
7.	None	39
8.	Bordeaux (as 4)	29
9.	Dusted with Copper-lime dust on Feb. 9th	28
10.	Ditto	35

Summary of Treatments.

1.	Control	85	Rusted Shoots
2.	A.P.S.	64	„ „
3.	Copper-lime dust	63	„ „
4.	Bordeaux	58	„ „
5.	Washed	35	„ „

It will be seen that the rust infection was this year only slight. Despite this the same result is evident as in last year's trials, namely that thorough washing of the "roots" prior to planting gives considerable control.

II. Similar experiments were carried out at Long Ashton, the mint having been grown in outside beds previously. These beds were heavily infected with teleutosori of the rust in October 1931. There were roots from 16 plants in each of the greenhouse beds except in the case of the lime-sulphur bed, which were from 9 plants.

Bed No.	*Treatment.*	*Total No. of Rusted Shoots.*	*Total No. of Bunches of Mint Gathered.*
1.	Control	111	78
2.	,, ...	74	149
3.	Tar Oil	84	228
4.	Washed thoroughly with hose	62	184
5.	Lime Sulphur	37	31

In the tar oil treatment the plants were cut down to the ground on October 20th and the old tops were removed. The plants were thoroughly sprayed with 5% neutral high-boiling tar oil wash on November 4th. In the lime-sulphur treatment the plants were sprayed on the latter date with 1-30 lime-sulphur. All the "roots" were planted in the greenhouse on November 18th. The plants treated with lime-sulphur were late in producing shoots, and the subsequent growth was very poor.

It will be seen that here again the most satisfactory treatment was thorough washing. It is probable that even better control could be got if the lifting and planting were done at an earlier date, but it is the custom of most of the growers in this area to carry out these operations in December or January.

Diseases of Peas.

Pea "Sickness" and Foot Rot.

In our 1929 report, we referred to a foot rot of peas which is very common in the Evesham area and appears to be of great economic importance. The disease is characterised by necrosis and blackening of the cortical tissues of the base of the stem and the topmost roots, and a consequent early dying off of the plants (Plate I, Fig. 1).

Experiments described in our 1930 report indicated that a characteristic *Fusarium* had been isolated constantly from diseased plants in that year. Comparison with descriptions of *Fusarium Martii* var. *Pisi** (5), which causes a stem and root rot of peas in

* Following the new nomenclature introduced by Wollenweber in 1931, the name of this fungus is *Fusarium Solani* var. *Martii* (App. et Wr.) Wr.

the United States, and with a culture of this *Fusarium*, originally from F. R. Jones, indicated that our fungus was in all probability identical with it, and preliminary trials of 41 varieties of peas in infected soil led us to hope that several varieties might be resistant.

In 1931, we found that the trouble was a more complex one than we had at first supposed. It was discovered that where the symptoms were most severe there was also present, on the roots of the plants, the eelworm *Heterodera schachtii* (Plate I, Fig. 2).

In 1932, subsequent to a heavy rainfall in April and May, both foot rot, and foot rot accompanied by *Heterodera*, appeared in epidemic proportions throughout Worcestershire. Although in some cases the direct effect of flooding simulated foot rot it was easy to ascertain whether fungus infection was present or not. Again, although in badly drained fields there were marked differences of infection in well drained and waterlogged areas, typical foot rot could also be found in areas where there could not be any question of unsatisfactory drainage.

Careful examination in 1932 of some twenty localities revealed the presence of foot rot only, while in seventeen other localities both foot rot and *Heterodera* were found. The latter were in addition to some seven localities discovered in 1931. The varieties "British Lion" and "Early Bird" were those most commonly affected with *Heterodera* and foot rot, but it should be borne in mind that these are among the varieties most commonly grown.

In Canada and the United States, France, Holland, Germany and Japan, there occur foot rots and wilts of peas caused by a large number of different *Fusaria*. Some of these, such as the foot rot of peas in the United States caused by *F. Martii* var. *Pisi*, greatly resemble the foot rot under consideration. Several writers, such as Horsfall, *et alia* (4), consider that the trouble, as it occurs in the State of New York, should be viewed as a "symptom complex," caused in some cases by a number of widely differing fungi, rather than a distinct and definite set of symptoms caused by a single fungus. This view is of interest in so far as certain American varieties of peas, such as "Green Admiral," "Yellow Admiral," "Rice's 330" and "Horal," appear to be resistant to foot rots and wilts caused by distinct fungi. The reason appears to be, as suggested by Gilchrist (3), that in these varieties there is a more resistant epidermis near ground level. This is usually associated with a definite lateness in the variety in question.

Pea variety trials were not carried out in the Evesham area in 1932, as it was felt that the cause of the trouble should first of all be more fully investigated, but observations were made regarding

the resistance or otherwise of many locally grown varieties. These are tabulated in the accompanying table, together with observations made during a small trial in 1930 (9), and information as to resistance or otherwise to *Fusarium* wilt in the United States, caused by *Fusarium orthoceras* var. *Pisi*, a quite distinct disease which does not occur in this country (7). It will be seen that there is a striking correlation between the two sets of data.

TABLE IV.

Resistance and Susceptibility of Pea Varieties to Foot Rot of Peas in the Evesham Area and to the American Fusarium Wilt of Peas, as Given by Walker (13).

S = susceptible. R = resistant. H = Heterodera schachtii also present.

Variety.	*Field Trial* 1930.	*Field Observations* 1931.	*Field Observations* 1932.	*Response to Fusarium. Wilt.*
Admiral Beatty ..	S	S	..	..
Bedfordshire Champion	S	..	..	..
Blue Bird	S	..	..	..
British Lion	S (partly)	S	S (+H)	..
Carter's Eight Weeks ..	..	S (+H)	..	..
Early Bird	..	S (+H)	S (+H)	S
Eclipse	..	..	S	S
Eldorado	S	..	..	S
Early Giant Marrowfat	S	..	..	..
Foremost	..	..	S (+H)	..
Freedom	S	..	..	..
Gradus	S	..	..	S
Hundredfold	S	..	..	S
Kelvedon Wonder ..	S	..	..	..
Laxtonian	S	..	..	S
Laxton's Progress ..	S	S (+H)	S (+H)	S
Laxton's Superb ..	S	S (+H)	S	..
Little Marvel	S	..	..	..
Maid of Kent	..	..	S (+H)	..
Marvellous	S	..	..	S
Meteor	S	..	S (+H)	..
Onward	..	S (+H)	S	S
Pilot	S	S	..	S
Pioneer	S	..	S	..
Primo	S	..	..	..
Sensation	..	S (+H)	..	..
Springtide	..	..	S	S
Superb	..	S	..	S
Talisman	S	..	..	S
Telegraph	..	..	S (+H)	..
Thomas Laxton ..	..	..	S	..
Tip Top	S	..	S	..
Unique	S	..	..	..

TABLE IV—*continued.*

Variety.	*Field Trial 1930.*	*Field Observations 1931.*	*Field Observations 1932.*	*Response to Fusarium Wilt.*
Alderman	R	..	..	R
Cheltonian	R	..	..	..
Duke of Albany ..	R	..	..	R
Dwarf Defiance ..	R	..	..	..
Gladstone	R	..	..	R
Liberty	R	..	..	..
Lincoln	R	..	..	R
President .. .. (=Union Jack)	R	..	..	..
Queen	R	..	..	..
Royal Salute	R	..	..	..
Senator	R	..	..	R
Standard	R	..	..	..
Witham Wonder ..	R	..	..	..

More extended trials of likely varieties are to be laid down in 1933. Meanwhile growers who contemplate sowing in infected ground are advised to avoid those varieties listed as susceptible, and to consult us regarding a choice of variety.

The exact role played by *Heterodera schachtii*, where this eelworm is also present, has still to be ascertained. The eelworm is well known in peas on the Continent, where, more particularly in association with a fungus identified as *Fusarium vasinfectum* var. *Pisi*, it can apparently cause severe damage (1). In her recent paper on the eelworm on peas (12), M. J. Triffit states that J. Rees also found a *Fusarium* foot rot associated with the presence of *Heterodera* in the case of a similar trouble in the Cardiff vicinity. We have found peas badly affected with *Heterodera schachtii* only. In this case there was no apparent check to growth. It should perhaps be pointed out that where *Heterodera*, *Heterodera* plus *Fusarium*, or *Fusarium* alone are present, there is a marked absence of root nodules.

An infection experiment was carried out with *Heterodera schachtii* as follows :—

On November 12th, 1931, a 19 ft. x 2½ ft. bed was made up in a cold greenhouse, and about 15 lb. of soil obtained from an infected field at Evesham were scattered over the surface as evenly as possible, and forked in. Peas of var. " Early Bird " were then sown. The average day temperature at the time of sowing was 48-52° F. Germination took place on November 23rd. *Heterodera schachtii* were first found on the pea roots on April 22nd, and by the 12th of May were present on almost every root. The following

weeds growing on the plot were unaffected by the eelworm : charlock (*Brassica Sinapis*), purple dead-nettle (*Lamium purpureum*), *Euphorbia Peplus*, groundsel (*Senecio vulgaris*), sow thistle (*Sonchus arvensis*), grass (*Poa annua*), chickweed (*Stellaria media*), Shepherd's purse (*Capsella Bursa-pastoris*) and bittercress (*Cardamine hirsuta*). The pea plants were also affected with a typical root rot, from which a fungus considered to be identical with *Fusarium Martii* var. *Pisi* was isolated.

The roots of many of the plants were left in the soil and the bed was resown with peas on May 19th by Dr. C. L. Walton, who is now co-operating with us on the eelworm side of the question, but no infection of the plants with *Heterodera* resulted.

In order to discover whether manurial systems had any marked effect on the disease, a trial was laid down at Hinton Cross, near Evesham, through the kindness of Mr. W. J. Newman. The piece of ground in question was known to be badly infected with *Heterodera* and foot rot fungi. The plots measured 36 ft. x 47 ft., and were as follows :—Control ; sulphate of ammonia (2½ cwt. per acre) ; sulphate of potash (4 cwt. per acre) ; control ; dung (1 ton per plot), when ploughed ; sulphate of ammonia (as above) ; Sulphate of potash (as above) ; dung (as above) ; control. The ammonia and potash were divided into two equal parts, the first dressing being applied in January, the second in late May. The seed, of the variety " British Lion," was sown on March 7th, 1932, and appeared above ground on April 5th, 1932. There were no apparent differences, due to the treatments, in the height of the plants, the amount of infection by *Heterodera*, or the time of dying off.

Crop weights were taken, with the following results :—

	200 *severely affected Plants from sides of rows.*		100 *less severely affected Plants from centres of rows (which were higher than the rest).*	
Ammonia ..	2 lb. 2 oz. 3 lb. 7 oz. } 5 lb. 9 oz.		5 lb. 4 oz. 5 lb. 12 oz. } 11 lb. 0 oz.	
Potash	2 lb. 4 oz. 1 lb. 13 oz. } 4 lb. 1 oz.		5 lb. 12 oz. 4 lb. 13 oz. } 10 lb. 9 oz.	
Control	1 lb. 10 oz. 1 lb. 6 oz. } 3 lb. 0 oz.		4 lb. 12 oz. 5 lb. 9 oz. } 10 lb. 5 oz.	
Dung	1 lb. 5 oz. 1 lb. 9 oz. } 2 lb. 14 oz.		4 lb. 12 oz. 5 lb. 8 oz. } 10 lb. 4 oz.	

It will be seen that the difference in yield between badly affected and less severely affected strips was very considerable, indicating that none of the treatments exercised a significant control of the disease. Sulphate of ammonia and sulphate of potash, and

Fig. 1.

Fig. 2.

Plate I.

FIG. 3.

FIG. 4.

PLATE I.

Fig. 1.

Plate II.

Fig. 2.

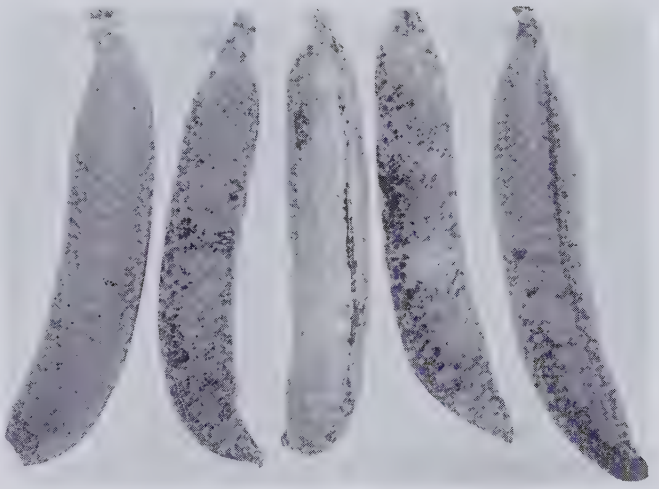

Fig. 3.

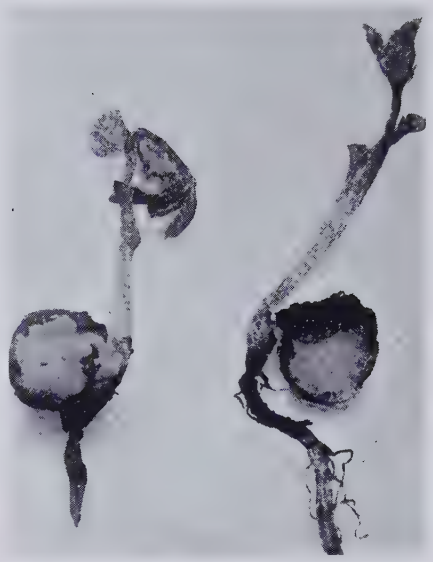

Fig. 4.

Plate II.

especially the former, at the rates applied, improved the crop slightly in both badly affected and less severely affected strips.

Leaf and Pod Spots.

As indicated in last year's report, both *Ascochyta Pisi* and *Mycosphaerella pinodes* are concerned in the production of leaf and pod spots of peas throughout the Province, while the latter also causes foot rots during the early growth of the plants (Plates I and II). The leaf and pod spots are not usually of serious importance during comparatively dry seasons, but given favourable wet weather at podding time much pod infection may result. We were fortunate in having collected during 1931 a large quantity of seeds infected with both fungi. These were used for experiments in 1932.

Seed Treatments.

I. *In Pots.* In this experiment batches of 50 pea seeds of the variety "Union Jack" taken from pods covered with lesions caused by both *Ascochyta Pisi* and *Mycosphaerella pinodes* were treated in various ways and sown in sterilised soil in pots in the greenhouse on 26th October, 1931. The results are shown in the following table :—

TABLE V.

Treatment.	*Nos. of Seeds Germinated (after 22 days).*	*Per cent. Healthy Plants on 2.3.32 (after 68 days).*
1. Hot water .. .. (30-35° C. for 2 hrs. then 50-52° C. for 15 mins.)	33	22
2. Ceresan .. .. (2 oz. per bushel, thoroughly shaken).	45	68
3. Granosan .. .. (4 oz. per bushel, thoroughly shaken).	4	4
4. Mercuric chloride .. .. .. (1-1,000 for 30 mins.).	45	38
5. Formalin .. .. (1-240 for 30 mins.)	49	30
6. Copper carbonate (dry) .. .. .. (2 oz. per bushel, thoroughly shaken).	43	20
7. Potassium permanganate .. .. (1 oz. per gallon for 30 mins.)	48	62
8. Uspulun .. .. (0.25% soln. for 15 mins.)	47	32
9. Controls	46	18

Photographs of some of the diseased plants are reproduced in Plates I and II. Plate II, Fig. 4 shows a typical "foot rot" from which *Mycosphaerella pinodes* was isolated. Plate I, Fig 4 shows lesions due to *Ascochyta Pisi*. It will be seen from the table that a fairly satisfactory control was given by both Ceresan and

potassium permanganate. The former had the peculiar effect of preserving the cotyledons in a firm state for a long time. On February 2nd, 1932, the healthy plants were on the average 6 cm. taller than the plants affected with foot rot. Plate II, Fig. 1 illustrates the effect of the two treatments compared with control plants. For some unknown reason the plants in the permanganate treated series did not make strong growth.

II. *In the Field.* Three rows of peas, 500 seeds per row, from similar infected seeds were sown side by side in the open at the Research Station on March 10th, 1932. The treatments and results are indicated in the table below.

TABLE VI.

Treatment.	*Germination* 12.4.32.	*No. of Plants having leaf spots* 9.5.32.	*Crop Weights.*	*Pod Infection with A. Pisi.*
1. Potassium permanganate (as in Expt. I).	70%	12	31½ lbs.	3.5%
2. Ceresan	77%	8	33 lbs.	5.4%
3. Control	64%	8	29½ lbs.	13.75%

Here again both Ceresan and potassium permanganate gave satisfactory results in the control of the disease.

III. *Infection from Debris.* In this experiment a short row of the variety "Early Bird" was sown in the open. A similar short row was sown adjoining, but old pods bearing *Ascochyta Pisi* lesions were scattered under the seeds as they were sown. 2% of the pods of the crop of the first row were infected with *Ascochyta Pisi,* and 50% of the pods of the second row.

IV. *Percentage Infection of Seeds.* Samples of the above-mentioned seed, 50 seeds per sample, which had been grown at Long Ashton in 1931, and saved from pods heavily infected with *Mycosphaerella pinodes* and *Ascochyta Pisi,* were placed on damp filter paper in Petri-dishes for eight days at room temperature.

1. Var. "Union Jack" .. Pods with *Ascochyta Pisi* lesions produced 50% infected.
2. „ „ .. Pods with *Mycosphaerella pinodes* produced 54% infected.
3. Var. "Radio" .. .. Pods with *Ascochyta Pisi* lesions produced 60% infected.
4. „ „ .. .. Pods with *Mycosphaerella pinodes* produced 62% infected.

This experiment shows the large percentage of infected seeds which may result from heavy pod infections.

V. *Laboratory Test of Treatments.* 50 infected seeds (25 per dish) of var. " Radio " were placed on damp filter paper in Petri-dishes after treatment, as in experiment 1, with Ceresan dust, Uspulun, potassium permanganate, and mercuric chloride. Infected seeds were removed as soon as mycelium appeared.

Total numbers removed : Ceresan, 21 = 42%
Potassium permanganate, 27 = 54%
Uspulun, 21 = 42%
Mercuric chloride, 25 = 50%
Control, 28 = 56%

It will be seen that in this experiment the organic mercury disinfectants prevented the growth of the fungus on the seeds to a considerable extent. It is probable that the most efficient fungicides, *i.e.* the mercury compounds, kill only the fungus on the surface of the seeds, hence of the seeds of " Radio " in question some 40% were healthy, 20% infected superficially and 40% with infection reaching to the inside of the cotyledons.

In the case of the variety " Union Jack " some 50% of the seeds were infected, hence we should expect that of the others some 17% were infected superficially and 33% in the cotyledons, and that the most efficient fungicide (but one not affecting the fungus in the interior of the seeds) would produce approximately 68% germination, and such was the case. It is probable that to give any better germination some heat or other treatment which would reach the fungus in the interior of the seeds would be necessary.

VI. *Treatments of Commercial Seed Samples.* Seven commercial seed samples (approximately 1 peck of each) obtained from various growers in the Evesham area, were treated with Ceresan (2 ozs. per bushel) in order to ascertain whether the treatment had any stimulating effect on growth, apart altogether from any question of disease control. There was a slight increase in the germination of the treated as compared with untreated lots, no increase in the heights of the plants, and only in one case an increase in the crop weights.

The germination counts were as follows :—

TABLE VII.

		Treated.	*Untreated.*	*Percentage increase in germination.*
1.	18 ft. of row	152 plants	130 plants	6
2.	„ „	183 „	174 „	5
3.	12 ft. of row	95 „	95 „	0
4.	18 ft. of row	204 „	198 „	3
5.	„ „	101 „	86 „	17
6.	„ „	149 „	145 „	3

Average percentage increase in germination = 6.

Inoculation Experiments.

Isolations were made from affected pods, leaf spots and foot rots and the resulting fungi compared with cultures originally from L. K. Jones, of New York, U.S.A. Pea plants were then artificially infected, by direct inoculation with mycelium and by spraying with spores of our own cultures and known cultures of *Ascochyta Pisi*, *Mycosphaerella pinodes*, and *Ascochyta pinodella*. As a result it was found that *Ascochyta Pisi* and *Mycosphaerella pinodes* were the two fungi commonly causing pod and leaf spots of peas in the Bristol Province, the symptoms being identical with those described by Jones (6). *Ascochyta pinodella* has not been found here. All the cases of typical foot rot under observation were caused by *Mycosphaerella pinodes*, and not by *Ascochyta Pisi*.

The Causes of Early Failure of Pea Plants.

It has been pointed out by other investigators (6) that *Ascochyta Pisi* cannot cause a typical "foot rot" and we are disposed to agree with this statement. In our 1930 report we described a case of failure of pea plants from Worcestershire, which we recorded as a "foot rot," in which two acres of plants had been so severely affected that they had to be ploughed in. "The lesions on the plants were typical of those caused by *Ascochyta Pisi*, being brown and sunken, and occurred mainly at or below ground level." The identification of the fungus in question has now been fully confirmed as *Ascochyta Pisi* and not *Mycosphaerella pinodes*. We now consider, however, that the plants in question were not affected with a typical "foot rot," as the lesions did not occur below the cotyledons. The case was of interest, however, in showing that *Ascochyta Pisi* can cause a total failure of stand of pea seedlings.

A more exact demonstration of how this can be brought about was given by the behaviour of the seedlings in Experiment 1 above. The seeds in question had been naturally infected with both *Ascochyta Pisi* and *Mycosphaerella pinodes*. Of eighteen unhealthy plants investigated five weeks after sowing, nine were infected with *Mycosphaerella pinodes*, seven with *Ascochyta Pisi*, and two with both fungi. The lesions due to *Ascochyta Pisi* are pale brown and sunken, and occur usually, though not always, above ground. Infection apparently comes from the cotyledons, portions of the stem which come in contact with the cotyledons during germination becoming infected. The lesions on these seedling plants usually penetrate well into the stem and in this way, or by killing off the tips of the shoots, bring about complete failure of the seedling. Abundant pycnidia are also produced on the stem lesions, spores from which bring about further infection of the apical portions of the plants.

Mycosphaerella pinodes, on the other hand, affects the underground parts of the seedling, the epicotyl and the hypocotyl. The whole of the stem circumference is affected, so that death of the plant soon takes place. The lesions are at first dark brown, later black.

Diseases of Onions.

Botrytis Disease. Further surveys have shown the prevalence of the *Botrytis* disease of spring onions throughout the Province.

Parsnip Diseases.

"*Canker.*" In the course of further work on the so-called parsnip "canker," which is very prevalent throughout the Province, our opinion has been strengthened that much of the so-called "canker" in the area is entirely due to injury by dipterous larvae. A large number of fungi associated with "cankers" have been tested for their pathogenicity, but only the fungus described last year as a *Phoma* has been found to be capable of producing cankers. Some of the spores of this fungus, which is probably the same as that described by Cotton (2), have been found to be septate, hence it should be placed in the genus *Ascochyta*.

Vegetable Marrow Diseases.

Mosaic. Work on marrow mosaic was continued. Seeds which had been kept from diseased fruits were sown in sterilised soil in an insect-free room at Long Ashton. One mosaic plant was secured from 256 seeds sown under these conditions.

Through the kindness of Mr. J. F. Bomford, a piece of ground at Spring Hill, Fladbury, on which very severe infection occurred during the last two years, was again used for observations. 70 seedling marrows were raised in the Institute greenhouses and were planted out on the edges of the field, and on two neighbouring plots where marrows had not been grown previously. The plants were all free from mosaic on May 26th when they were planted out. Mosaic was first noticed on three widely separated plants on June 30th. The greatest spread of the disease was observed on July 28th. By August 25th, only 27 plants of the 70 remained healthy. There appeared to be some connection between plants of *Bryonia dioica* bearing mottled leaves and areas of greatest spread. This plant was also usually associated with the presence of the disease in other fields.

Little progress has been made in ascertaining the common vector of the disease or alternative host plants, although many experiments were carried out with these objects in view.

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PLATE I.

Pea Diseases.

Fig. 1. Foot Rot of Peas.

Fig. 2. Pea "Sickness." Cysts of *Heterodera schachtii* on roots.

Fig. 3. *Ascochyta Pisi* on pea pods.

Fig. 4. Lesions of *Ascochyta Pisi* on pea seedlings.

PLATE II.

Mycosphaerella pinodes on Peas.

Fig. 1. Seed treatments. Plants grown in sterilised soil from affected seeds. Left: Potassium permanganate treatment. Centre: Control Right: Ceresan treatment.

Fig. 2. Leaf spots.

Fig. 3. Pod spots.

Fig. 4. Seedling foot rot due to *Mycosphaerella pinodes*.

RING SPOT OR SPOTTED WILT OF TOMATOES AND ORNAMENTAL PLANTS.

By L. Ogilvie.

In April, 1932, my advice was sought with regard to a disease of tomatoes which had become prevalent in certain commercial glasshouses in Wiltshire, affecting several hundred plants. The symptoms were a slight mottling of the leaves, the mottling often taking the form of definite concentric rings. In older plants the young leaves were definitely bronzed and tended to curl downwards somewhat, while the plants apparently stopped growing. In the later stages the symptoms resembled those of "streak," there being necrotic spots on the stems and mottling of the fruits.

Since these symptoms appeared to resemble those of the virus disease known as "ring spot," first recorded from England in 1929 and described by Dr. Kenneth M. Smith in 1931 (3) and in later papers (4) (5), specimens were sent to the latter and the identification was duly confirmed. Subsequently Dr. Smith has come to the conclusion that this disease is identical with the very serious tomato disease known in Australia as "spotted wilt," which has been investigated there by Samuel and others (1, 2).

The disease was also found in 1932 in at least two localities in Somerset and the object of the present note is to point out its seriousness to tomato growers and nurserymen.

There is as yet no definite information that the disease is transmitted through tomato seed, but this seems unlikely, as both English and Australian investigators have found that the virus is apparently not present in the fruits. On the other hand once tomatoes are affected in greenhouses the disease is liable to spread to other plants, and if these are perennials they remain a continuous source of infection. The transmitting agent has been shown by Smith to be the common greenhouse thrips *Thrips tabaci*. In Australia, however, in outdoor conditions the thrips *Frankliniella insularis* is mainly responsible. In both cases adult thrips are unable to transmit the virus, but it is easily transmissible by the larvae.

Smith has found that most Solanaceae are susceptible, as are lupins, petunias, dahlias, asters, zinnias and nasturtiums. Among the plants found in a mixed greenhouse in Somerset to bear definite ring spots were *Streptosolen Jamesonii, Schizanthus sp., Browallia speciosa major, Trachelium sp., Begonia sp.* and *Campanula pyramidalis*. The presence of the disease on these plants has been confirmed by Smith. The disease probably occurs also on many other plants. Suspected chrysanthemums have been found, but the presence of the disease on chrysanthemums in England has not been confirmed, although the spotted wilt of Australia has been transmitted to chrysanthemums in that country.

In the nurseries of a commercial grower of ornamental plants in Somerset a large number of dahlias were found to show conspicuous ring spots on the leaves and the possibility of widespread dispersal of the disease by the sale of such plants may be realised.

The control of the disease once it is introduced into greenhouses is difficult unless the grower has a keen eye for the symptoms, and growers who suspect its presence should submit specimens immediately to the Advisory Mycologist.

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ILLUSTRATIONS.

"Spotted wilt" or "ring spot" on (1) Dahlia ; (2) Begonia.

Fig. 1.

Fig. 2.

DOWNY MILDEW OF HOPS IN THE BRISTOL PROVINCE IN 1932.

By L. Ogilvie and C. E. Pearson.†

Incidence of the Disease.

It was expected that the severe epidemic of downy mildew in 1931 would lead to an equally severe epidemic in the spring of 1932 owing to overwintering mycelium in the stumps and overwintering spores (oospores) in the ground. Such proved to be the case. Basal spikes were first reported on April 24th, and from then onwards large numbers of spikes continued to be produced on "Mathons," "Bramlings," "Goldings" and other susceptible varieties, in many cases over 90% of the rootstocks being infected. "Fuggles" in most cases remained practically free from spikes. Thus on one farm a yard of Bramlings was so badly spiked that the owner decided to grub them. In the neighbouring Fuggles yard only about ten spikes were found.

Several growers had followed the suggestion put forward by Salmon in the previous year, and had applied copper dusts to the stumps at an early date but, in common with similar trials carried out in Kent,* no appreciable reduction in the number of spikes was apparent. Growers as a whole were now very much alive to the seriousness of the situation and continuous spiking was done. Prolonged heavy rains through practically the whole of April and May were highly conducive to production of conidia and spread of infection. Late in May there was evidence of much infection of the ends of the shoots, "terminal spikes" being produced in which there was little or no thickening of the stem, but in which the leaves were crowded together in the usual fashion. In one case some 80% of the plants were so affected.

Fortunately about this time when the outlook was a disastrous one and growers were spiking almost continuously, there came a complete change in weather conditions. From June 1st to June 28th there was only one day of slight rain. By the end of the month, when the bines were at the top of their wires, the incidence of the disease was only slight.

Several growers commenced spraying with Bordeaux mixture before the bines reached the top and no serious damage by scorching

† Agricultural Inspector, Ministry of Agriculture and Fisheries.

* Salmon, E. S. Address at Hop Growers' Conference, Wye, Jan. 11, 1933. (Reported in "Fruit Grower," 75, Jan. 19, 1933, p. 103).

occurred. By the beginning of July spraying was common all over the area.

Although July was warm and the rainfall was slight, there were usually showers and heavy dews every day, so that spraying was certainly necessary. Weather conditions during August were ideal for the ripening of the cones, 23 days of the 31 being quite free from rain.

Hop picking commenced about August 29th and finished about a month later. On the whole the incidence of downy mildew was very slight. Many growers of " Fuggles " gave only one spraying but were able to reap a satisfactory crop. The crop was a light one of very high quality.

It should be noted that a peculiar russetting of the cones took place in several districts. This was especially common in the Teme Valley, Bramlings being affected most severely. Although in some cases aphides seemed to be associated with the injury, it is probable that most of it was a sun-scorch effect.

The incidence of the disease in the West of England corresponds well with the description given by Salmon of conditions in the Eastern Counties. There both terminal and lateral spikes were common in June, and a shortage of bine became apparent. The 1932 crop in the Eastern Counties was free or practically free from downy mildew. As a result of this year's experience, Salmon recommends three sprayings as a routine measure, no matter what the weather may be, namely, when the bines have reached the top, just before burr stage and immediately after. No damage appears to accrue from spraying the plants during burr, but it is inadvisable to spray the cones. The last two sprayings should be heavy, of the order of 350-400 gallons per acre.

Hop Disease Advisory Scheme.

The Hop Disease Advisory Scheme for the Bristol Province formulated last year functioned satisfactorily and will be continued (in conjunction with the County Agricultural Authorities and the Worcestershire and Herefordshire Hop Growers' Society) in 1933.

A system of recording hop diseases in the area has been adopted, and it is hoped will be carried on for several years. 53 farms were investigated in 1932. Many hop disease specimens were sent to Long Ashton for diagnosis. Three spraying demonstrations were arranged by the County Agricultural Organisers for Hereford and Worcester, and were largely attended. On the whole, it may be said that Herefordshire and Worcestershire growers are now well aware of the necessity of spraying their hops and well acquainted with the methods of doing so.

MELAMPSORA AMYGDALINAE, THE RUST OF BASKET WILLOWS (*SALIX TRIANDRA*).

I. OBSERVATIONS AND EXPERIMENTS IN 1932.

By L. Ogilvie and H. P. Hutchinson.

In the Annual Report of the Research Station for 1931 a preliminary account was given of the biology of the rust fungi which attack basket willows, and particularly of *Melampsora Amygdalinae*, the cause of "rust cankers" on rods of the species *Salix triandra*. The present article describes some further observations and experiments carried out in 1932.

Environmental Relationships.

Rainfall and Maximum Temperatures (Long Ashton).

	Rainfall.		*Maximum Temperatures.*	
	1931.	1932.	1931.	1932.
April ..	2.72 in.	3.56 in.	65°F. on 11th.	59°F. on 30th.
May ..	3.47 in.	5.93 in.	72°F. on 27th & 28th.	67°F. on 19th.
June ..	3.50 in.	1.42 in.	75°F. on 4th.	78°F. on 27th.
July ..	4.45 in.	2.72 in.	73°F. on 3rd.	76°F. on 12th.
August ..	3.96 in.	1.21 in.	76°F. on 4th.	93°F. on 19th.
September ..	2.95 in.	5.82 in.	68°F. on 16th.	75°F. on 15th & 17th.

Weather Conditions. The spore germination experiments described in Part II give some explanation of the marked correlation which can be observed between the incidence of the rust and weather conditions. The summer of 1931 was cool and wet, circumstances very favourable to infection by and spread of the uredospore stage. This resulted in a disastrous infection of the rods with "rust cankers."

The dry weather during parts of the winter of 1931–32, especially during February, appears to have killed the teleutosori on the old leaves to some extent. At any rate, despite a heavy infection of the old leaves with the teleutospore stage, there was not an abundant production of oecidia in the spring, except in damp areas in the beds, despite favourable wet weather for their development during April and May. During these two months, however, there was a rapid spread of uredospore infection. Fortunately, the very dry weather in June, July and August and the high temperatures

prevailing during August put an effective check to the further spread of the rust. The ultimate effect was seen on the mature rods, on which there were comparatively few rust cankers.

First Appearance, etc. The following dates refer to stumps of autumn-cut " Black Maul " in South Somerset, except where otherwise stated ; (most other varieties commence shoot growth later than " Black Maul "). The buds began to turn green during the last week in March. Overwintered cankers on cut rods in pits were beginning to produce uredospores on April 15th, while oecidia were first seen on the shoots and lower leaves of plants in the field on April 22nd, and were plentiful on April 29th. On the 26th the shoots were $\frac{1}{2}$—$1\frac{1}{2}$ins. long. To provide a check on these field observations overwintered leaves bearing teleutosori had been gathered from fields in South Somerset on April 1st. They were suspended in glass jars over " Black Maul " cuttings (from healthy plants previously grown in the greenhouse) in damp sand in pots in the open on April 2nd. The first oecidia on the leaves of these cuttings appeared on April 23rd. The production of oecidia on " Black Maul " in Somerset in 1932 may therefore be safely said to have commenced during the fourth week in April.

In an endeavour to find out how long teleutospores remained viable on the old leaves and could continue to give rise to sporidia and consequent oecidial production, old leaves bearing teleutospores, gathered on April 1st, which had been suspended over willow shoots and had given rise to oecidia were again suspended over clean shoots on April 26th. There was a further slight production of oecidia. The leaves were again suspended over fresh shoots on May 17th, but no oecidial infection resulted.

Again, old leaves recently gathered were suspended plentifully over twelve plants in outside beds on May 18th, but no infection resulted. The teleutospores on the old leaves had therefore ceased to become infective by May 18th, and the duration of infectiveness was at most a month.

Position of Oecidia. Oecidial cankers were found mainly on the lowest leaves and the stem bases, but occasionally they were observed on the fourth or fifth leaf from the ground and in one case five inches above the ground. This is about the height the shoots would have reached about the 12th of May.

Overwintering Cankers on Uncut Rods. It was pointed out in last year's remarks that it is important to cut off the rods well down to the ground in order to prevent the overwintering of cankers on the plants. If rods are allowed to remain uncut on the headlands they will also naturally tend to provide infection for entire

fields. Cankers on such old rods were found to be producing uredospores on April 29th. Such uredospore production appears to continue for about a month.

Fungicides.

Bordeaux Mixture. On April 16th, three plants of " Black Maul " in pots were sprayed with Bordeaux mixture (5–7½–50, made with hydrated lime), and overwintered leaves were suspended over them in the usual way. None of the plants in question became affected with the rust, while a control plant produced abundant oecidia.

Copper-lime Dust. On account of the difficulties involved in the effective application of wet sprays to willow plantings, it was determined to concentrate as far as possible on the use of copper-lime dust.

Small Trials. These were carried out on small plots of " Black Maul," through the courtesy of Mr. A. C. Willy, of Drayton, Messrs. Greinter, Jeans & Parsons, Langport, Mr. Musgrave, of Athelney, and others.

I. Dusts applied April 1st and April 20th, very thoroughly all round the stumps. 20 stumps dusted gave 5 oecidial cankers, while 20 control stumps gave 17 cankers. In this field, unfortunately, the infection was so slight that no conclusive results were obtained. In the trial in question, however, there seems to have been some protective action. It should be noted that the ground was flooded at the time of the first application.

II. Dusts applied April 22nd. In this strip unfortunately infection in both dusted and control plots were so slight as to give no conclusive results.

Large Trials. The large scale trials were carried out on " Black Maul " and " Champion Red " fields belonging to Mr. R. B. Taylor, at West Moor, near Kingsbury Episcopi. It was not possible to carry out a very early dusting in this case, as in the case of the small trials, but it was hoped that the trials would show whether it is possible to keep down uredospore infections sufficiently by one or two applications throughout the summer. The applications were made at the rate of 60lb. per two acres.

The results were as follows :—

(*a*) " Black Maul." Two applications, May 3rd—4th and June 21st. Counts of 100 rods gave the following results : 3, 2, 3, 3, 4, 5, 6, 2, 3, and 1 canker in each case. Total, 34 cankers per 1000 (3.4% infection).

(*b*) " Black Maul." Three applications, the last on July 26th.

Counts of 100 rods gave the following results : 4, 5, 8, 5, 3, 4, 0, 1, 2, and 0 cankers in each case. Total, 32 cankers per 1000 (3.2% infection).

(*c*) " Champion Rod." One application, May 3rd—4th. Counts of 100 rods gave the following results : 1, 0, 5, 3, 6, 3, 0, 2, 3, and 3 cankers in each case. Total, 26 cankers per 1000 (2.6% infection).

(*d*) Check field. This was an adjoining field of " Black Maul." Counts of 100 rods gave the following results : 3, 6, 2, 0, 3, 3, 3, 4, 3 and 0 cankers in each case. Total, 27 cankers per 1000 (2.7% infection).

It will be seen that there was no appreciable difference between dusted and undusted fields. In fact the infection in all the fields was so small as to be negligible. Most of the cankers were at a height of about 2 feet. This fact is probably to be correlated with heavy rains at the end of May, which would wash the spores down from the leaves on to the stems.

Effect of Destroying the First Shoots.

However efficient the fungicide applied, the rapid growth of the willow shoots makes protection of the leaves a very difficult problem, and to give adequate protection it would seem that very frequent applications must be necessary.

It will be seen, however, that the problem would be solved if by some means the young shoots could be entirely protected during a period of about three weeks in April and May. This can be brought about by two methods, (1) by late cutting of the rods, whereby the emergence of the buds is thrown back several weeks, and (2) by destroying the earliest shoots when they are 2—3 inches long.

Inquiries amongst growers elicited the information that in cases where parts of a field had been burnt over the shoots produced subsequently appeared to be as vigorous as the original ones and more rust free. It is also not unusual for sheep to be turned into withy fields at an early period in the growth of the rods. The effects were similar in this latter case.

The effects of tar oil winter washes applied to willow stumps during the winter had been investigated at Long Ashton in 1931, and in the spring of 1932 one of the foremost growers determined to carry out an experimental application of these washes on a large scale.

An application of 10% " Mortegg " was therefore made to a field of " Black Maul " and " Spaniard " on April 20th—25th and on a field of mixed varieties on April 25th. At that time the shoots

were about 2ins. long. Heavy rains interfered with these applications and second applications were therefore made in both cases a fortnight later (about May 4th). In part of the first field 15% "Mortegg" was used.

The effects noticeable on June 9th were as follows: The original shoots had mostly been killed off, but not entirely, owing probably to rains at the time of the applications. Fresh buds had broken, giving shoots which were now 4 or 5 inches behind the normal length. Counts on oecidial infections on shoots and leaves were made on a low-lying part of the treated plants and on comparable plants of an immediately contiguous part of the field adjoining (which had not been treated and which was separated only by a fence) with the following results:—

"Spaniards" (treated)	.. Infections on 50 stumps:	118.
"Spaniards" (untreated)	.. Infections on 50 stumps:	5980.
"Black Maul" (treated)	.. Infections on 50 stumps:	5.
"Black Maul" (untreated)	.. Infections on 50 stumps:	2070.

On July 26th the following observations were made: In the treated fields the "Spaniards" were particularly vigorous and healthy, 5ft. 6ins. to 6ft. high. Rust (uredospores) was slight on the leaves, having probably spread from the adjoining untreated field. The "Black Mauls" were very healthy and 4ft. 6ins. to 5ft. high. There was some rust on the side of the field adjoining the untreated field. On the other side rust was slight.

The untreated "Spaniards" and "Black Mauls" were 5ft. 6ins. to 6ft. high. Rust was plentiful on the leaves.

The tar oil emulsion had a very marked effect in killing off most of the weeds, thus saving labour in weeding and in cleaning the stumps from moss. No damage appeared to have been done to the stumps.

The results of the above experiment are promising and lead one to suppose that if the treatment were carried out on a large scale satisfactory control of the rust might be secured with little trouble. Owing to heavy rains at the time of one of the applications, however, it is perhaps unsafe to make any recommendations without further trails and it is hoped that these will be carried through in 1933.

Summary.

1. Weather conditions in 1932 were unfavourable for the production of any serious damage to basket willow rods by the rust canker fungus *Melampsora Amygdalinae*.

2. Teleutospores of the rust on overwintered leaves of " Black Maul " appeared to have become infective about April 10th and to have remained infective for four to five weeks. The first oecidia appeared on April 22nd.

3. Owing to the slight occurrence of the rust, the small scale and large scale trials with copper-lime dust did not yield any conclusive results.

4. Two applications of tar oil winter washes, the first about April 20th and the second on May 4th, when the shoots were about 3 inches long, had the effect of killing off the first shoots. The shoots which appeared subsequently were much less free from rust in their early stages and produced excellent rods of normal length. Further trials of this method must be made, however, before it can be recommended for general use.

MELAMPSORA AMYGDALINAE, THE RUST OF BASKET WILLOWS (*SALIX TRIANDRA*).

II. SPORE GERMINATION EXPERIMENTS.

By L. Ogilvie.

The rust fungus of basket willows (*Salix triandra*), which has been identified as *Melampsora Amygdalinae* Kleb., brings about very great damage in damp seasons, since the uredospore stage attacks the rods while they are still green, causing the appearance of cankers which render them of practically no value.

In any attempt to arrive at a means of control of this disease, it is of the first importance to ascertain accurately the response of the uredospores to various environmental conditions, chemicals, etc. This work was carried out in the summer of 1932.

Experimental.

The methods employed were those used by S. E. A. McCallan in his recent "Studies on Fungicides" (2). The uredospores used in the course of the experiments were taken from cankers on rods of *Salix triandra* which had been cut off and kept in water in the laboratory. Under such conditions a continuous crop of uredospores is produced for several weeks. The spores were placed in drops of water on clean glass slides in a large moist chamber sealed with water, as described by McCallan.

Germination in Tap Water, Distilled Water, etc.

Date.	*Medium.*	*Light or Dark.*	*Temperature.*	*Germination (after three days).*
2.8.32	Tap Water.	Dark.	20-22°C.	96% *in a count of* 120.
,,	Distilled Water.	,,	,,	100% ,, ,, ,, 120.
,,	Willow Leaf Extract.	,,	,,	approx. 100% ,, ,, ,, 200.

The results show that the spores germinate practically equally well, in all three media. Because of the possibility of traces of copper, etc., being present in tap water, distilled water was used in all the later experiments.

Light and Dark.

Date.	*Medium.*	*Light or Dark.*	*Temperature.*	*Germination (after 26 hours).*
11.9.32	Distilled Water.	Dark.	17.5°C.	89.5% *in a count of* 874. (Av. deviation from mean of 4 counts, 4.9).
11.9.32	Distilled Water.	Light.	17.5°C.	94.7% *in a count of* 900. (Av. deviation from mean of 4 counts, 1.4).

The above results indicate that light and dark have no significant influence on germination.

Temperature.

I.

Date.	*Medium.*	*Light or Dark.*	*Temperature.*	*Germination (after 26 hours).*
27.8.32.	Distilled Water.	Dark.	22-24°C. (incubator).	62.8% *in a count of* 411. (Av. deviation from mean of 3 counts, 11.0). The spores had just germinated, and there was no further growth.
,,	,,	,,	20-22°C. (laboratory)	Av. germination 97.5% *in a count of* 1567. (Av. deviation from mean of 11 counts, 1.2). Germ tubes long.
27.8.32	Distilled Water.	Dark.	18-19°C.	Av. germination 97.1% *in a count of* 1282. (Av. deviation from mean of 9 counts, 1.2).
25.8.32.	Distilled Water.	Light.	17.5—19.5°C.	Av. germination 95.0% *in a count of* 2649. (Av. deviation from mean of 21 counts, 1.6).

II.

29.8.32.	Distilled Water.	Light.	18°C.	Av. germination 89.4% *in a count of* 1436. (Av. deviation from mean of 12 counts, 5.5).
29.8.32.	Distilled Water.	Light.	16°C.	90.0% *in a count of* 1165. (Av. deviation from mean of 10 counts, 7.2).

These experiments indicate that above 23°C. there is a marked diminution in germination.

Further experiments were carried out at a later date on the effect of extremes of temperature, with the following results :—

Date.	*Light or Dark.*	*Temperature.*	*Germination.*
28.9.32	Dark.	1°C. (Cold store) for 24 hours, then at 18°C.	No germination in cold store 44.2% *in a count of* 276 after subsequent treatment.
28.9.32	Dark.	24°C. for 24 hours (incubator), then 24 hours at 18°C.	33.7% (just germinated) *in a count of* 489. No further growth.
		24°C. for 48 hours, then 24 hours at 18°C.	23.5% (just germinated) *in a count of* 531. No further growth.
28.9.32	Light.	18°C. (control) for 27 hours.	82.5% *in a count of* 568. Germ tubes normal.

The deleterious effect of a temperature above 23°C. is again apparent. This temperature appears to kill the spores.

Effect of High Temperatures on Dry Spores.

A fresh leaf bearing sori was placed in a small tightly corked tube and kept at a temperature of 24–25°C. for 24 hours. At the end of this period the leaf appeared quite fresh. A suspension of the spores was prepared in the usual way and kept at 16–18°C. 24 hours later no germination had occurred and all the spores had cleared (*i.e* were dead).

Effect of Low Temperatures on Dry Spores.

Dry spores were placed on a slide in the cold store at 1°C. for 17 hours, and were then germinated in the laboratory in the ordinary way.

Date.	*Medium.*	*Light or Dark.*	*Temperature.*	*Germination.*
16.9.32.	Dry at 0–1°C. for 17 hours, then in distilled water.	Light.	14–20°C.	93.5% *in a count of* 218.
16.9.32.	Distilled Water. (Control).	Light.	14–20°C.	94.8% *in a count of* 293.

Humidity.

Uredospores were placed in a saturated and in a normal atmosphere respectively in glass dishes in the usual way. In the one case the bottom of the dish was covered with moist filter paper and in the other case the dish was dry. The experiment took place in the light at a temperature of 15–20°C. In the moist chamber no germination took place till a week later when condensation drops came in contact with the spores, which then germinated in the usual way. Those in the dry chamber had not germinated three weeks after the start of the experiment and at the end of this period were normal in appearance.

It appears therefore that actual contact with water is necessary for germination.

Lack of Air.

A spore suspension in distilled water was made on a clean slide and another slide was placed over it in the manner of a cover-glass. No germination took place. Other samples of the same suspension showed normal germination in 24 hours.

Rate of Growth of Hyphae.

Measurements made on 8.8.32 showed that the germ tubes at the commencement of growth are capable of growing 8.75μ in five minutes in tap water at 21°C.

A spore suspension in tap water was prepared at 11.5 a.m. on 9.8.32 at a temperature of 22°C. Germination had commenced at 12.45 p.m. At 2.45 p.m. the mycelia were about 148μ long. The following measurements were made at subsequent intervals (an average growth of 1.2μ per minute) :—

Time.	*Interval in minutes.*	*Time from start in minutes.*	*Growth Lengths of Mycelium in μ.*
3.12 p.m.		0	
3.19 ,,	7	7	3
3.34 ,,	15	22	4
4.04 ,,	30	52	6
4.26 ,,	23	75	11
4.40 ,,	14	89	15
4.50 ,,	10	99	18

Growth plotted against time gives practically a straight line.

Effect of Fungicides.

The wet fungicides were sprayed on the slides and allowed to dry in an incubator at 24°C. The dry fungicides were dusted very finely on a wet slide. The spore suspensions were then applied in the usual manner. The slides with the various fungicides were placed in separate dishes, as were the control slides.

(*a*) *Bordeaux mixture.*

(1 g. copper sulphate and 1.5 g. hydrated lime to 500 cc. water. This is one-fifth the usual strength).

Date.	*Medium.*	*Light or Dark.*	*Temperature.*	*Germination (in 28 hours).*
6.9.32.	0.2% Bordeaux mixture.	Light.	About 17°C.	(No germination. All spores had cleared.)
6.9.32.	Distilled Water. (Control).	Light.	About 17°C.	92.1% *in a count of* 1185.

(*b*) *Lime sulphur.*

(" Home-made " lime sulphur prepared by boiling 3g. lime and 1.5g. sulphur for 45 mins. in 40cc. water, and diluting to about 100cc.).

Date.	*Medium.*	*Light or Dark.*	*Temperature.*	*Germination (in 28 hours).*
6.9.32.	Lime sulphur. Control as in (*a*).	Light.	About 17°C.	5.1% *in a count of* 1489.

(*c*) *Ammonium polysulphide.*

(Stock A.P.S. was diluted with distilled water at the rate of 1 in 200 and the slides dried as above).

Date.	*Medium.*	*Light or Dark.*	*Temperature.*	*Germination (in 28 hours).*
6.9.32.	A.P.S. 1 in 200.	Light. . .	About 17°C.	89.2% *in a count of* 1050. Germ tubes short. (Av. deviation from mean of 4 counts, 5.6).
6.9.32.	Distilled Water. (Control).	Light.	About 17°C.	95.8% *in a count of* 1043. (Av. deviation from mean of 4 counts, 2.3).

(*d*) *Burgundy mixture.*

Date.	*Medium.*	*Light or Dark.*	*Temperature.*	*Germination (in 21 hours).*
8.9.32.	Burgundy Mixture. (4.5.50).	Light.	14°C.–16°5°C.	No germination. All spores had cleared.
8.9.32.	Distilled Water. (Control).	Light.	14°C–16°5°C.	92.8% *in a count of* 325.

(*e*) *Sulphur* (*Flowers of Sulphur*).

I.

Date.	*Medium.*	*Light or Dark.*	*Temperature.*	*Germination (after 48 hours).*
24.9.32.	Distilled Water and Flowers of Sulphur.	Light.	16–19.5°C.	76.0% *in a count of* 1025.
24.9.32.	Distilled Water. (Control).	Light.	16–19.5°C.	80.8% *in a count of* 990.

II.

5.9.32.	Distilled Water and Flowers of Sulphur.	Light.	16–18°C.	88.7% *in a count of* 1025.
5.9.32.	Distilled Water. (Control).	Light.	16–18°C.	65.5% *in a count of* 793.

The low percentage of germination in the control is probably to be explained by the presence of a trace of copper from a previous test. In any consideration of the toxicity of sulphur to the fungus it should be noted that willow leaves do not react with sulphur to form hydrogen sulphide.

(*f*) *Copper lime dust.*

Date.	*Medium.*	*Light or Dark.*	*Temperature.*	*Germination (after 20 hours).*
5.9.32.	Distilled Water and Copper Lime Dust.	Light.	16–18°C.	No germination. Spore contents colourless.
	Distilled Water. (Control).	As in Sulphur II.		

(*g*) "*Shirlan*" (*Salicylanilide*).

The 0.25% "Shirlan" mixture—3 oz. Shirlan, 1.5 oz. Agral I, and 4 galls. water—was sprayed on the slide and allowed to dry.

Date.	*Medium.*	*Light or Dark.*	*Temperature.*	*Germination (after 23 hours).*
21.9.32.	Distilled Water and Shirlan. (0.25%).	Light.	About 17°C.	No germination. All spores cleared.
21.9.32.	Distilled Water. (Control).	Light.	About 17°C.	78.2% *in a count of* 617.

(*h*) *Various dilutions of Copper Sulphate.*

I.

Date.	*Medium.*	*Light or Dark.*	*Temperature.*
16.9.32.	Various dilutions of Copper Sulphate and Distilled Water.	Light.	18.5–19.5°C.

Conc. $CuSO_4.5H_2O$.	*Approx. Cu per 1,000,000.*	*Percentage germination (after 17 hrs.)*		*Count*
0.00625%	15.81	0	Spores colourless and shrunken.	/∞
0.003125%	7.90	0		/∞
0.00156%	3.95	0		/∞
0.0007812%	1.97	5.5	Spores unchanged.	523
0.0003906%	0.98	7.8	,, Tubes very short.	476
Distilled Water. (Control).	0	95.0	Normal.	509

II.

Date.	*Medium.*	*Light or Dark.*	*Temperature.*
19.9.32.	Various dilutions of Copper Sulphate and Distilled Water.	Light.	14–16.5°C.

Conc. $CuSO_4.5H_2O$.	*Approx. Cu per 1,000,000.*	*Percentage germination (after 27 hrs.)*		*Count*
0.00156%	3.95	0		/∞
0.000781%	1.97	16.6	Tubes very short.	829
0.0003906%	0.98	71.7		645
0.0001953%	0.49	81.6	Tubes medium.	370
0.000097%	0.24	92.1	Long tubes.	330
Distilled Water (Control).	0	86.4	Long tubes.	354

III.

Date.	*Medium.*	*Light or Dark.*	*Temperature.*
23.9.32.	Various dilutions of Copper Sulphate with Distilled Water.	Light.	14.5–15.5°C.

Conc. of $CuSO_4.5H_2O$.	*Approx. Cu per 1,000,000.*	*Percentage germination. (after 23 hrs.)*		*Count.*
.000195%	0.49	66.6	Tubes short. Spore colour unchanged in most cases.	613
.0003906%	0.98	52.2	,,	486
.00058%	1.45	0	Spores unchanged.	/∞
.000781%	1.97	0	Very short germ tubes in several spores. Most spores colourless.	/∞
.00117%	2.93	0	No germination. Spores mostly colourless.	/∞
.00156%	3.95	0	No germination. Spores nearly all colourless and shrunken.	/∞
Distilled Water (Control).	0	81.4	Long tubes.	740

It appears from the above experiments that a concentration of only .00058% copper sulphate in distilled water, or about 1.5 parts metallic copper in a million, may entirely prevent germination of the uredospores.

Discussion.

Several points of considerable practical importance have been brought out by the above experiments.

Those dealing with the influence of temperature and moisture explain why the disease is so much more serious in wet and cool seasons and why there is a very noticeable check to its spread during periods of high temperature, as noted during August of 1932.

The rapid germination of the spores and growth of the hyphae under favourable conditions emphasises the potentiality of rapid spread of the disease.

The environmental relationships of the uredospores resemble those of the flax rust *Melampsora Lini*, as described by Hart (1). In this case the optimum temperature for germination was about 18°C., while beyond the range of 6°C. and 23°C. the percentage of germination decreased, and the germ tubes were short and weak. Germination tests in light and darkness gave similar results; contact with water was necessary for germination; and germination under favourable conditions commenced after $1\frac{1}{2}$ hours.

The effects of various fungicides on spore germination agree with those of the field control trials which have already been carried out. The extreme susceptibility of the spores to traces of copper is especially interesting. It may be noted here that little careful work appears to have been done on the reaction of rust spores to chemicals.

Summary.

The uredospores of *Melampsora Amygdalinae* germinated equally well in tap water, distilled water and willow leaf extract, and in light and dark.

There is a noticeable check to germination of the spores in water at about 24°C. Prolonged exposure to temperatures near 0°C. also has a checking effect.

Temperatures around 24°C. apparently kill the dry spores, while temperatures near 0°C. have little killing effect.

Under favourable conditions germination commences in about an hour and a half and the germination tube subsequently elongates at the rate of about 1.2μ per minute.

Germination was entirely prevented by 0.2% Bordeaux mixture, 1% Burgundy mixture and 0.25% " Shirlan " (Salicylanilide), while A.P.S. 1 in 200 and flowers of sulphur had only a slight checking effect. Lime sulphur at " foliage strength " materially checked germination.

A solution of .00058% copper sulphate in distilled water entirely prevented germination. This is equivalent to a concentration of about 1.5 parts of copper per one million.

No germination can take place unless the spores are in contact with liquid water.

Air is required for germination.

These results agree with field observations.

Acknowledgment.

The writer has much pleasure in acknowledging the valuable assistance of Mr. H. M. Hutchinson, who carried out all the determinations recorded in the paper and contributed several useful suggestions.

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CIDER MAKING TRIALS FOR THE SEASON 1931-32.

By V. L. S. Charley and P. T. H. Pickford.

The 1931 cider apple crop was again below average in most districts. In some parts of Somerset, however, the crop was fairly good.

The average specific gravity of the freshly expressed juices examined at Long Ashton was 1.0486. This was rather low, although nearly two points higher than in 1930.

The quality of the cider was very fair and better than was anticipated after the very unfavourable summer. The juices were characterised by a rather high acid and tannin content. The tannin content was outstandingly high in the "Sweet" ciders.

The Cider and Perry Competitions.

For the seventh year in succession a series of competitions on similar lines to those described in earlier reports was arranged.

82 entries of fruit were received. Of these 75 were apples and 7 were pears. The fruit was stored until fit for milling, and the subsequent treatment given to each cider or perry was the same, except for the following differences as to the filtration period. In Classes I, II and VI, the ciders and perries were filtered when the specific gravity of the fermenting juices was 1.030; in Classes III and IV, the filtration gravity was 1.025.

The Competitions were open to growers residing in the counties of Devon, Dorset, Gloucester, Hereford, Monmouth, Somerset and Worcester. The entries from the different counties were distributed as follows:—Devon, 15; Gloucester, 8; Hereford, 13; Monmouth, 11; Somerset, 34; Worcester, 1.

The Ciders and Perries were judged on April 19th, 1932, by the Hon. J. W. Best, Melplash, Dorset; Messrs. W. R. Bufton, Widemarsh, Hereford; E. G. F. Walker, Chew Stoke, Bristol; and J. H. Wootton, Byford, Hereford.

Class I (Kingston Black) obtained 9 entries of a rather marked similarity in the ultimate product. They were good clean ciders, but with no outstanding quality.

Class II (Sharp Varieties) was, as in the two previous years, divided into two groups :— (i) with an acidity of 0.80% or above, (Group A) ; (ii) with an acidity below 0.80%, (Group B). Group A comprised ciders which can only be suitably used for blending with ciders of low acidity, whereas the ciders in Group B can be used unblended. Group A (9 entries) was not on the whole an attractive collection. Several had a rather coarse flavour with a very harsh penetrating acidity. No. 16, Sour Cluster, was considered the best ; No. 17, Ashwell Redstripe, and No. 18, Hartisman, were both good clean ciders, the latter especially having a well blended acid and a pleasant flavour. No. 10, White Sharp, had a clean flavour, but the acid was too penetrating. Group B (10 entries) was much more attractive. The flavours were more pleasant on the whole, but again the acidity and, more especially, the tannin were very marked. No. 21, Langworthy, was awarded the 1st Prize. It was a full-bodied cider, softer than most of the others and with a slight pleasant aroma. No. 19, Breakwell's Seedling, was a light, medium brisk cider with only a fair body and colour. No. 25, Wyatt's Seedling, had a good fruity flavour with a slightly acid aroma. One of the best in the group was No. 27, Skyrmes Kernel, a full bodied cider with an acidity not too pronounced, but full and suggestive of a well balanced blend of acid. This cider had just a slight aroma.

Class III (Sweet Varieties) with 13 entries was the outstanding class in the competition. The acidity and tannin being much higher than usual for this type of apple, they gave a more aromatic flavour than is generally found in these ciders. They were less insipid and made a more interesting sweet class than usual. No. 41, Perthyres, was considered the best. This was a nice sweet cider with a " nutty " flavour and a bouquet resembling champagne ; despite too much fermentation the flavour and aroma were very pleasant and delicate. No. 37, Woodbine, was not up to standard for this variety. It had a full flavour, but was slightly coarse, with a rather acid aroma. No. 33, Sweet Alford, was a rich full cider with a decided fruity aroma. No. 29, Sweet Alford, had a particularly pleasant flavour with the typical aroma of sweet varieties.

Class IV (Bittersweet Varieties) with 20 entries was also a good class. They were nearly all useful ciders but, as their character was lighter than usual for this class, the tannin stood out rather prominently. Knotted Kernel, No. 50, was awarded the 1st Prize. This was a fine coloured cider with a pronounced astringency. No. 48, Tremlett's Bitter, was rather coarser than many of the others, and had not quite such a pleasant aroma. Royal George,

No. 42, was fairly pleasant and had a well-balanced aroma, but there was a rather coarse tannin flavour. Cherry Norman, No. 43, was one of the best in the class. It was a good bitter-sweet cider with a fruity flavour, agreeable bitter taste and a very good aroma. No. 55, Dabinett, had a flavour influenced by fermentation in bottle, but the cider was characteristic of many bittersweet varieties useful for blending. The excess of fermentation in bottle is probably accounted for by the fact that the fruit was from young trees. No. 58, Royal Jersey, was a typical Somerset bittersweet cider with the tannin and the acidity noticeable in the aroma.

Class V for Blends (14 entries). This class was treated on the same lines as last year, except for the following differences : — Whereas last year the two blends A and B were made by the Institute, this year the exhibitors were invited to state the proportions for one blend (A), the Institute determining the proportions for a second blend (B). As before, the samples were obtained in the respective cases by making blends of the ciders entered by a single individual in the sharp class and either or both of the sweet and bittersweet class.

The blends were very variable in quality; although many produced excellent ciders, several were very unbalanced in flavour owing to the unsuitability of the particular combinations of ciders available for the individual blend. In these latter ciders the acidity and tannin were too pronounced and did not blend well in the flavour.

No. 62 B, which was considered the best, was a very pleasant, well balanced brisk cider. No. 64 A was of good quality and character with a rather soft flavour. Nos. 74 A and 74 B were very similar, but 74 A was a particularly good cider and had an interesting " silky " flavour. No. 66 A was a cider with a nice aroma, but the tannin was rather too prominent on the palate. No. 68 B was one of the best of this class. It had a rich, full flavour, although the tannin was too prominent.

Class VI, for Perries (7 entries), was disappointing. It was evidently a poor year for perry, and all the entries were below the average quality. No. 77, a Blakeney Red, which was awarded 1st Prize, was a pleasant drink with a softer flavour than the others of that variety. No. 76, (second prize), Blakeney Red, was again quite pleasant, but possessing a rather biting character. No. 79, Blakeney Red, was a nice bright perry with an attractive pear flavour. This was awarded the third prize. No. 78, the Blakeney Red from Monmouth, was outstanding in having a remarkably strong pear-flavoured aroma. No. 81, Oldfield, was disappointing for this variety. Although it had a delicate bouquet, the flavour was very dry.

Non-Competitive Ciders.

Jersey Varieties. Three varieties of apples were sent for trial from Jersey. Bellfield, No. 83, was of fair quality, not very rich, but useful for blending. No. 84, Romeril, was a useful sweet cider. No. 85, Bretagne, made a pleasant drink by itself, being light and brisk.

Ciders made from the Somerset Trial Orchards. No. 86, Dymock Red, was a useful mild cider, but it lacked briskness. No. 87, Cherry Pearmain, had a rather coarse flavour but a slight pleasant aroma. No. 88, a sharp unnamed variety, had not much character, but was quite brisk. The Medaille d'Or was unpleasant with a hard tannin flavour. No. 90, Broadleaf Norman, was lacking in character, flavour and aroma. No. 91, Yarlington Mill, had a very dry flavour, but the after taste was pleasant. Brown Snout, No. 92, was an agreeable soft cider with no excess of tannin noticeable. No. 93, Hereford Redstreak, was a good cider for blending, with a very pleasant, fruity, acid flavour. Cummy Norman, No. 94, had an unattractive taste on the palate at first, but was quite pleasant in the after taste.

Ciders from Long Ashton Trial Orchard. The best of these were No. 95, Dufflin, which was a very good, well rounded cider with a fruity flavour, and No. 96, Dymock Red, which possessed a considerable aromatic fruity flavour and aroma. No. 97, Neverblight, was inferior to No. 96, but a useful blending cider, although the acid was rather raw. Knotted Kernel, No. 98, had a fine, clean bittersweet flavour. Chisel Jersey, No. 99, was a typical medium acid bittersweet, with a rough tannin flavour. No. 100, Tardive Forestier, had a coarse flavour. No. 101, Harry Masters' Jersey, was a clean medium cider, useful for blending. Dabinett, No. 102, was not up to standard for this variety. It was lacking in quality and rather poor in flavour.

Report of Judges on the Long Ashton Cider Competitions 1931-32.

Judging took place on April 19th, 1932.

The entries in the single-variety classes numbered 68 and in addition there were 28 blends. As compared with other recent years the total number is rather small: the falling-off is fully accounted for by the failure of the cider apple crop in 1931 and is less than might have been expected.

In spite of the unfavourable summer and the indifferent grade of fruit resulting therefrom, the quality of the ciders as a whole

exceeded anticipation. While this cannot be ranked as a first-class vintage year, a large proportion of the ciders, when suitably blended, proved of sufficient quality to produce an agreeable light, clean drink of moderate alcoholic strength. The specific gravity of the fresh expressed juices averaged, somewhat unexpectedly, distinctly higher than in the previous year. Acidity and tannin were conspicuous, both in actual amount and outstanding effect on the palate : the tannin in particular was abnormally high in the " Sweet " class.

In Class I, for Kingston Black apples only, there were 9 entries and all yielded good, very clean ciders, quite characteristic of the variety. There was relatively little difference between the best and the worst in the class, quality being unexpectedly high for the season although not outstanding in any instance.

The 9 entries in Class II, Section A, for sharp apples of high acidity, suited only for blending, were characterised by an exceptionally penetrating acid flavour, which tended to harshness of character and lack of attractive quality. They were particularly clean, but otherwise inferior to the standard of a good vintage year.

Section B of this class, for varieties with a rather lower range of acidity, contained 10 entries. The flavour of these was generally more pleasant than that in Section A, but here also acidity and tannin—the latter in particular—stood out unusually prominently on the palate. The prizewinning entries were pleasant, light drinks, fairly suitable for use unblended.

Class III, for sweet varieties, with its 13 entries, was the feature of this year's Competitions. Usually a dull class without distinctive character, on this occasion it was composed of a series of very pleasantly flavoured ciders of very good quality on the whole. They were rather on the light side ; but this, with the acidity and tannin more conspicuous than usual, made them more attractive and less insipid than the fuller bodied type generally associated with this class in most years.

Class IV, with 20 entries of bittersweet varieties, was also a very good class. In nearly all cases the ciders were very useful for blending and some were of high merit. There was a general absence of the typical heavy-bodied bittersweet character, although the tannin stood out rather prominently because of the light nature of most of these ciders.

The 28 Blends of which Class V was composed, were very irregular in merit. The best stood out by themselves, but many were unattractive because of the predominant manner in which the

acidity and tannin came through on the palate. This defect was due to the fact that in such cases the individual ciders available to make the blend could not be satisfactorily balanced in a season of this description. A considerable improvement would have been possible, had the competitors in these cases included apples of the sweet class. On this account the entries fall naturally into two groups—the good and the inferior—and the gap in quality between the two was very marked. The ciders gaining awards may be considered as very good for the season.

The Perry Class, Class VI, secured 7 entries. None of the perries were outstanding in quality, and there was very little to choose between the four prizewinners. Every entry was clean and in good general condition, but the class was well below the average of a good perry year, and the season was clearly not suitable for this beverage.

In conclusion, special mention should be made of the manner in which both ciders and perries had been managed in this difficult season. There was a complete absence of taints throughout, the flavour being exceptionally clean, and those responsible for the cider-making may be warmly congratulated on the condition of all the entries.

(Signed) James W. Best.
William R. Bufton.
Eldred G. F. Walker.
John H. Wootton.
Judges.

(*For Tables see the following pages*).

TABLE I.

CIDERS. COMPETITION VARIETIES.

No.	Name of Variety.	Date of making.	Specific Gravity of Fresh Juice.	Malic Acid per cent.	Tannin per cent.	Rate of fermentation.	Date of Filtering.	Specific Gravity at time of Filtering.	Specific Gravity May, 1932.	Name and Address of Grower.
	CLASS 1.—Kingston Blacks—									
1	Kingston Black ..	17/11/31	1.055	0.54	0.20	7.0	23/12/31	1.030	1.030	H. E. Dabinett, Somerton, Som.
2	,, ,, ..	17/11/31	1.059	0.72	0.26	5.3	13/1/32	1.030	1.030	Major C. Jackson, Charlton Mackrell, Som.
3	,, ,, ..	17/11/31	1.051	0.60	0.20	5.0	6/1/32	1.030	1.030	G. Breakwell, Perthyre, Mon.
4	,, ,, ..	17/11/31	1.057	0.63	0.22	5.3	20/1/32	1.030	1.030	E. T. Bryant, Leycroft, Taunton, Som.
5	,, ,, ..	17/11/31	1.059	0.72	0.25	7.7	23/12/31	1.030	1.029	J. Dennis & Sons, Churcham, Wor.
6	,, ,, ..	17/11/31	1.058	0.68	0.23	5.7	12/1/32	1.030	1.029	W. R. Thomas, Nunnington, Her.
7	,, ,, ..	17/11/31	1.061	0.70	0.26	5.0	27/1/32	1.030	1.030	W. Hill, Beardley, Kittisford, Som.
8	,, ,, ..	17/11/31	1.058	0.69	0.24	4.7	23/1/32	1.030	1.030	G. P. Hallett, Charlton Adam, Taunton, Som
9	,, ,, ..	17/11/31	1.054	0.66	0.23	4.3	13/1/32	1.030	1.030	T. J. Frampton, Barton St. David, Som.
	CLASS 2A.—Sharp Varieties. Acidity 0.8 per cent. or above—									
10	White Sharp ..	16/10/31	1.046	0.93	0.14	5.2	10/11/31	1.030	1.026	W. H. Hunt, Easton-in-Gordano, Som.
11	Court Apple ..	4/11/31	1.043	1.03	0.16	9.5	10/11/31	1.030	1.022	W. Ludlow, Westbury-on-Trym, Glos.
12	Gloucester Never-blight ..	4/11/31	1.044	0.85	0.11	8.0	10/11/31	1.030	1.028	,, ,, ,, ,,
13	Frederick ..	10/11/31	1.053	1.10	0.11	4.8	10/12/31	1.030	1.030	S. J. Mullins, Dingestow, Mon.
14	Frederick ..	13/11/31	1.046	0.97	0.10	5.5	2/12/31	1.030	1.029	G. Breakwell, Perthyre, Mon.
15	Winter Stubbets	13/11/31	1.043	0.83	0.17	9.2	21/11/31	1.030	1.020	J. Walters & Sons, Newton St. Cyres, Devon.
16	Sour Cluster ..	20/11/31	1.045	0.85	0.27	6.0	8/12/31	1.030	1.030	S. F. J. Clarke, Honiton, Devon.
17	Ashwell Redstripe	20/11/31	1.042	0.80	0.18	9.0	30/11/31	1.030	1.021	R. J. Denning, Ilminster, Som.
18	Hartisman ..	30/11/31	1.045	0.96	0.15	5.5	17/12/31	1.030	1.030	W. H. Hunt, Easton-in-Gordano, Som.

TABLE I.—*continued.*

CIDERS. COMPETITION VARIETIES.

No.	Name of Variety.	Date of making.	Specific Gravity of Fresh Juice.	Malic Acid per cent.	Tannin per cent.	Rate of fermentation.	Date of Filtering.	Specific Gravity at time of Filtering.	Specific Gravity May, 1932.	Name and Address of Grower.
	CLASS 2B.—MEDIUM SHARP VARIETIES. Acidity below 0.8 per cent.									
19	Breakwell'sSeedling	14/10/31	1.045	0.52	0.20	6.9	9/11/31	1.030	1.030	G. Breakwell, Perthyre, Mon.
20	Langworthy ..	10/11/31	1.044	0.55	0.15	6.0	26/11/31	1.030	1.028	J. Walters & Sons, Newton St. Cyres, Devon.
21	Langworthy ..	19/11/31	1.046	0.49	0.15	4.8	24/12/31	1.030	1.030	E. T. Bryant, Leycroft, Taunton, Som.
22	Norman	19/11/31	1.051	0.57	0.31	6.2	22/12/31	1.030	1.030	E. T. Lewis, Dymock, Glos.
23	White Sheep's Nose	20/11/31	1.044	0.79	0.28	5.2	4/12/31	1.030	1.030	S. F. J. Clarke, Honiton, Devon.
24	Sharp Apple ..	20/11/31	1.046	0.71	0.19	7.2	1/12/31	1.030	1.028	G. Williams & Son, Westhide, Her.
25	Wyatt's Seedling	27/11/31	1.046	0.54	0.15	5.0	10/12/31	1.030	1.030	W. J. Berry, Newton St. Cyres, Devon.
26	Sweet Blenheim ?	20/11/31	1.048	0.49	0.26	6.7	5/12/31	1.030	1.030	W. H. Hunt, Easton-in-Gordano, Som.
27	Skyrmes Kernel..	27/11/31	1.041	0.54	0.20	3.2	12/12/31	1.030	1.026	S. R. Plumley, Barton St. David, Som.
28	Medium Sharp ..	4/11/31	1.041	0.54	0.20	8.8	11/11/31	1.030	1.022	W. Ludlow, Westbury-on-Trym, Glos.
	CLASS 3.—SWEET VARIETIES—									
29	Sweet Alford ..	28/10/31	1.049	0.21	0.10	5.6	18/11/31	1.025	1.025	J. T. Shields, Berkeley, Glos.
30	Sweet Alford ..	4/11/31	1.048	0.27	0.14	5.5	30/11/31	1.025	1.025	F. Vincent, Pinhoe, Devon.
31	Sweet Alford ..	4/11/31	1.045	0.20	0.17	5.8	26/11/31	1.025	1.023	H. Daniel, Honiton, Devon.
32	Sweet Alford ..	6/11/31	1.048	0.30	0.18	4.3	23/12/31	1.025	1.025	S. Cursons, Dunsford, Devon.
33	Sweet Alford ..	27/11/31	1.048	0.26	0.17	5.2	29/12/31	1.025	1.024	W. J. Berry, Newton St. Cyres, Devon.
34	Sweet Alford ..	27/11/31	1.047	0.36	0.18	9.5	4/12/31	1.025	1.024	R. J. Denning, Ilminster, Som.
35	White Jersey ? ..	4/11/31	1.045	0.26	0.14	8.2	16/11/31	1.025	1.024	Major C. Jackson, Charlton Mackrell, Som.
36	Woodbine ..	17/11/31	1.057	0.37	0.26	5.0	25/1/32	1.025	1.025	W. Hill, Beardley, Kittisford, Som.
37	Woodbine ..	19/11/31	1.052	0.31	0.14	5.5	5/1/32	1.025	1.025	E. T. Bryant, Leycroft, Taunton, Som.
38	Woodbine ..	13/11/31	1.052	0.40	0.25	6.7	7/12/31	1.025	1.024	S. F. J. Clarke, Honiton, Devon.
39	Sheep's Nose ..	19/11/31	1.050	0.31	0.17	6.8	15/12/31	1.025	1.025	E. T. Bryant, Leycroft, Taunton, Som.

TABLE I.—*continued.*

	CIDERS.	COMPETITION VARIETIES.								
	CLASS 3.—Sweet Varieties—*contd.*									
40	Sweet Blenheim..	27/11/31	1.046	0.29	0.14	7.5	7/12/31	1.025	1.022	R. J. Denning, Ilminster, Som.
41	Perthyres ..	13/11/31	1.049	0.32	0.21	8.2	28/11/31	1.025	1.020	G. Breakwell, Perthyre, Mon.
	CLASS 4.—Bittersweet Varieties.									
42	Royal George ..	14/10/31	1.051	0.31	0.31	6.3	12/11/31	1.025	1.025	W. H. Hunt, Easton-in-Gordano, Som.
43	Cherry Norman ..	28/10/31	1.051	0.27	0.27	6.0	24/12/31	1.025	1.025	W. R. Thomas, Nunnington, Her.
44	Green Bittersweet	6/11/31	1.048	0.22	0.30	6.7	3/12/31	1.025	1.025	S. Cursons, Dunsford, Devon.
45	Broadleaf Norman	6/11/31	1.050	0.27	0.22	8.2	20/11/31	1.025	1025.	S. R. Plumley, Barton St. David, Som.
46	Royal Jersey ..	9/11/31	1.058	0.34	0.48	3.7	13/1/32	1.025	1.025	G. P. Hallett, Charlton Adam, Taunton, Som
47	Harry Masters Jersey	9/11/31	1.054	0.27	0.33	7.5	28/11/31	1.025	1.024	P. M. Frost, Christon, Axbridge, Som.
48	Tremlett's Bitter	10/11/31	1.048	0.39	0.36	4.3	24/12/31	1.025	1.025	F. Vincent, Pinhoe, Devon.
49	Belle Norman ..	13/11/31	1.047	0.34	0.34	5.5	30/11/31	1.025	1.025	E. Edwards, Norton Canon, Her.
50	Knotted Kernel	13/11/31	1.067	0.33	0.52	6.5	29/12/31	1.025	1.025	,, ,, ,, ,,
51	Strawberry Norman	13/11/31	1.053	0.40	0.44	7.5	30/11/31	1.025	1.023	,, ,, ,, ,,
52	Dove	13/11/31	1.046	0.39	0.31	6.0	8/12/31	1.025	1.025	H. E. Dabinett, Somerton, Som.
53	French	17/11/31	1.055	0.33	0.35	6.3	24/12/31	1.025	1.025	S. J. Mullins, Dingestow, Mon.
54	Chisel Jersey ..	17/11/31	1.052	0.29	0.40	5.3	29/12/31	1.025	1.025	J. Baker, Bassaleg, Mon.
55	Dabinett ..	17/11/31	1.046	0.24	0.26	6.0	11/12/31	1.025	1.024	,, ,, ,,
56	Leycroft Bitter ..	19/11/31	1.052	0.33	0.25	8.8	5/12/31	1.025	1.024	E. T. Bryant, Leycroft, Taunton, Som.
57	Brown Snout ..	20/11/31	1.044	0.39	0.25	7.2	2/12/31	1.025	1.023	T. R. Price Westhide, Her.
58	Royal Jersey ..	20/11/31	1.050	0.36	0.42	5.0	5/1/32	1.025	1.025	H. E. Dabinett Somerton, Som.
59	Strawberry Norman	27/11/31	1.046	0.33	0.32	5.2	19/12/31	1.025	1.024	S. R. Plumley, Barton St. David, Som.
60	Spotted Dick ..	10/11/31	1.051	0.36	0.27	8.3	25/11/31	1.025	1.022	S. F. J. Clarke, Honiton, Devon.
61	Red Norman ..	10/11/31	1.047	0.40	0.23	6.7	26/11/31	1.025	1.024	G. Williams & Son, Westhide, Her.

TABLE I.—*continued.*

CIDERS. COMPETITION VARIETIES.

No.	Name of Variety.	Date of making.	Specific Gravity of Fresh Juice.	Malic Acid per cent.	Tannin per cent.	Rate of fermentation.	Date of Filtering.	Specific Gravity at time of Filtering.	Specific Gravity May, 1932.	Name and Address of Grower.
	CLASS 5. The Ciders in this Class are Blends Made at the Institute from the respective Entries of Individual Competitors in Classes 1—4. From each competitor's set of single variety Ciders two blends, A and B, have been prepared, in proportions selected by the competitor himself (A) and by the Institute (B) respectively. The numbers in brackets are those of the single variety ciders in the preceding classes used for the blends.									
62A	Wyatt's Seedling(25) —1, Sweet Alford (33)—1	..	..	0.48	0.16	..	..	..	1.028	W. J. Berry, Newton St. Cyres, Devon.
62B	Wyatt's Seedling(25) —2, Sweet Alford (33)—1	..	..	0.55	0.16	..	..	..	1.028	W. J. Berry, Newton St. Cyres, Devon
63A	Kingston Black (3) —1, Frederick (14) 1, Perthyres (41) —4, Breakwell's Seedling (19)—1..	..	..	0.63	0.20	..	..	..	1.025	G. Breakwell, Perthyre, Mon.
63B	Kingston Black (3) —2, Frederick (14) —1, Perthyres (41) —2, Breakwell's Seedling (19)—1..	..	..	0.67	0.20	..	..	..	1.027	G. Breakwell, Perthyre, Mon.
64A	Kingston Black (4) —2, Langworthy (21)—1, Woodbine (37)—1, Leycroft Bitter (56)—2 ..	..	..	0.57	0.23	..	..	..	1.026	E. T. Bryant, Leycroft, Taunton, Som.

TABLE 1.—*continued.*

CIDERS. COMPETITION VARIETIES.

CLASS 5.—THE CIDERS IN THIS CLASS ARE BLENDS MADE AT THE INSTITUTE, ETC.—*contd.*

64B	Kingston Black (4)—2, Langworthy (21)—1, Sheep's Nose(39)—1,Woodbine (37)—1, Leycroft Bitter (56)—1	..	..	0.52	0.19	..	..	..	1.028	E. T. Bryant, Leycroft, Taunton, Som.
65A	Sour Cluster (16)—1, White Sheep's Nose (23)—1,Woodbine(38)—2,Spotted Dick (60)—1	..	..	0.67	0.28	..	..	..	1.027	S. F. J. Clarke, Honiton, Devon.
65B	Sour Cluster (16)—1, White Sheep's Nose(23)—1,Woodbine (38)—1,Spotted Dick (60)—2	..	..	0.62	0.27	..	..	..	1.027	S. F. J. Clarke, Honiton, Devon.
66A	Kingston Black (1)—1, Royal Jersey (58)—1, Dove (52)—1	..	..	0.53	0.32	..	..	..	1.028	H. E. Dabinett, Somerton, Som.
66B	Kingston Black (1)—2, Royal Jersey (58)—1, Dove (52)—3	..	..	0.56	0.30	..	..	..	1.028	H. E. Dabinett, Somerton, Som.
67A	Ashwell Redstripe (17)—1, Sweet Blenheim (40)—2	..	..	0.61	0.18	..	..	..	1.024	R. J. Denning, Ilminster, Som.
67B	Ashwell Redstripe (17)—2,Sweet Blenheim (40)—2,Sweet Alford (34)—1	..	..	0.69	0.20	..	..	..	1.024	R. J. Denning, Ilminster, Som.

TABLE I.—*continued.*

CIDERS. COMPETITION VARIETIES.

No.	Name of Variety.	Date of making.	Specific Gravity of Fresh Juice.	Malic Acid per cent.	Tannin per cent.	Rate of fermentation.	Date of Filtering.	Specific Gravity at time of Filtering.	Specific Gravity May, 1932.	Name and Address of Grower.
	CLASS 5.—The Ciders in this Class are Blends Made at the Institute, Etc.—*contd.*									
68A	Kingston Black (8)—1, Royal Jersey (46)—2	..	..	0.69	0.39	..	..	..	1.029	G.P. Hallett, Charlton Adam, Taunton, Som.
68B	Kingston Black (8)—2, Royal Jersey (46)—5	..	..	0.66	0.40	..	..	..	1.028	G.P. Hallett, Charlton Adam, Taunton, Som.
69A	Kingston Black (7)—1, Woodbine (36)—2	..	..	0.62	0.27	..	..	..	1.029	W. Hill, Beardley, Kittisford, Som.
69B	Kingston Black (7)—2, Woodbine (36)—5	..	..	0.58	0.26	..	..	..	1.028	W. Hill, Beardley, Kittisford, Som.
70A	Hartisman (18)—1, Royal George (42)—1, Sweet Blenheim (26)—1 ..	..	..	0.67	0.22	..	..	..	1.028	W. H. Hunt, Easton-in-Gordano, Som.
70B	Hartisman (18)—1, Royal George (42)—4, White Sharp (10)—1, Sweet Blenheim (26)—1	..	..	0.62	0.25	..	..	..	1.027	W. H. Hunt, Easton-in-Gordano, Som.

TABLE I.—*continued.*

CIDERS. COMPETITION VARIETIES.

CLASS 5.—The Ciders in this Class are Blends Made at the Institute, Etc.—*contd.*

71A	Kingston Black (2)—1, White Jersey (35)—2	..	..	0.56	0.17	..	..	..	1.027	Major C. Jackson, Charlton Mackrell, Som.
71B	Kingston Black (2)—2, White Jersey (35)—5	..	..	0.54	0.15	..	..	..	1.027	Major C. Jackson, Charlton Mackrell, Som.
72A	Frederick (13)—1, French (53)—1 ..	..	..	0.71	0.20	..	..	..	1.028	S. J. Mullins, Dingestow, Mon.
72B	Frederick (13)—1, French (53)—2 ..	..	..	0.62	0.25	..	..	..	1.027	S. J. Mullins, Dingestow, Mon.
73A	Skyrmes Kernel (27)—1, Broadleaf Norman (45)—1 ..	..	..	0.54	0.22	..	..	..	1.026	S. R. Plumley, Barton St. David, Som.
73B	Skyrmes Kernel (27)—1, Broadleaf Norman (45)—1, Strawberry Norman (59)—1 ..	..	..	0.51	0.27	..	..	..	1.025	S. R. Plumley, Barton St. David, Som.
74A	Kingston Black (6)—1, Cherry Norman (43)—2 ..	..	..	0.51	0.26	..	..	..	1.028	W. R. Thomas, Nunnington, Her.
74B	Kingston Black (6)—2, Cherry Norman (43)—5 ..	..	..	0.50	0.27	..	..	..	1.028	W. R. Thomas, Nunnington, Her.
75A	Sharp Apple (24)—1, Red Norman (61)—1	..	..	0.67	0.20	..	..	..	1.026	G. Williams & Son, Westhide, Her.
75B	Sharp Apple (24)—1, Red Norman (61)—3	..	..	0.57	0.22	..	..	..	1.025	G. Williams & Son, Westhide, Her.

TABLE I.—*continued.*
COMPETITION VARIETIES.

No.	Name of Variety.	Date of making.	Specific Gravity of Fresh Juice.	Malic Acid per cent.	Tannin per cent.	Rate of fermentation.	Date of Filtering.	Specific Gravity at time of Filtering.	Specific Gravity May, 1932.	Name and Address of Grower.
	CLASS 6.—PERRIES—									
76	Blakeney Red ..	27/10/31	1.046	0.44	0.15	5.4	23/11/31	1.030	1.030	R. C. G. Cotterell, Bridge Sollers, Her.
77	Blakeney Red ..	27/10/31	1.049	0.48	0.16	4.2	2/12/31	1.030	1.030	R. Evans, Norton Canon, Her.
78	Blakeney Red ..	27/10/31	1.045	0.45	0.11	4.4	23/11/31	1.030	1.030	S. W. Mullins, Raglan, Mon.
79	Blakeney Red ..	28/10/31	1.044	0.47	0.14	4.2	23/11/31	1.030	1.030	R. Hyett, Dymock, Glos.
80	Eley's Nonsuch ..	4/11/31	1.047	0.47	0.10	4.8	23/11/31	1.030	1.030	J. P. Eley, Frampton Cotterell, Glos.
81	Oldfield	10/11/31	1.049	0.69	0.10	9.0	23/11/31	1.030	1.027	G. Williams & Son, Westhide, Her.
82	Pine	19/11/31	1.044	0.64	0.10	9.5	28/11/31	1.030	1.027	J. Jones, Dymock, Glos.
	CIDERS MADE FROM APPLES FROM JERSEY.									
83	Bellfield	9/10/31	1.049	0.31	0.32	10.0	16/10/31	1.025	1.022	Jersey.
84	Romeril	19/11/31	1.050	0.37	0.20	8.5	5/12/31	1.025	1.023	,,
85	Bretagne ..	29/12/31	1.049	0.64	0.12	10.2	16/1/32	1.030	1.028	,,
	CIDERS MADE FROM THE SOMERSET TRIAL ORCHARDS.									
86	Dymock Red ..	9/11/31	1.052	0.48	0.14	5.5	20/11/31	1.030	1.026	P. M. Frost, Christon, Axbridge, Som.
87	Cherry Pearmain	9/11/31	1.051	0.67	0.24	7.8	19/11/31	1.030	1.026	,, ,, ,, ,,
88	Sharp Variety ..	9/11/31	1.049	0.79	0.14	9.2	16/11/31	1.030	1.027	,, ,, ,, ,,
89	Medaille d'Or ..	9/11/31	1.051	0.29	0.45	7.0	25/11/31	1.025	1.024	,, ,, ,, ,,
90	Broadleaf Norman	9/11/31	1.049	0.27	0.28	8.0	20/11/31	1.025	1.021	,, ,, ,, ,,
91	Yarlington Mill ..	9/11/31	1.051	0.34	0.29	6.7	30/11/31	1.025	1.023	,, ,, ,, ,,
92	Brown Snout ..	9/11/31	1.050	0.32	0.20	4.5	15/12/31	1.025	1.025	E. Dauntsey, South Barrow, Yeovil, Som.
93	Hereford Redstreak	9/11/31	1.048	0.75	0.12	7.5	20/11/31	1.030	1.027	S. R. Plumley, Barton St. David, Som.
94	Cummy Norman	9/11/31	1.060	0.33	0.28	7.5	30/11/31	1.025	1.025	,, ,, ,, ,,

(Competition Ciders Nos. 27, 45, 47 and 59 are also made from the Somerset Trial Orchards.)

TABLE I.—*Continued.*

PERRIES. COMPETITION VARIETIES.

CLASS 6.—PERRIES—*continued.*

CIDERS MADE FROM THE LONG ASHTON TRIAL CIDER ORCHARD.

95	Dufflin	16/10/31	1.046	0.91	0.18	4.8	7/11/31	1.030	1.028	Long	Ashton	Trial	Orchard.
96	Dymock Red ..	4/12/31	1.040	0.45	0.10	4.7	12/12/31	1.030	1.028	,,	,,	,,	,,
97	Never Blight ..	4/12/31	1.039	0.56	0.28	2.7	24/12/31	1.030	1.030	,,	,,	,,	,,
98	Knotted Kernel	5/11/31	1.054	0.24	0.34	7.0	24/11/31	1.025	1.024	,,	,,	,,	,,
99	Chisel Jersey ..	4/12/31	1.042	0.42	0.28	5.7	23/12/31	1.025	1.025	,,	,,	,,	,,
100	Tardive Forestier	4/12/31	1.042	0.40	0.45	4.0	29/12/31	1.025	1.025	,,	,,	,,	,,
101	Harry Master's Jersey	4/12/31	1.040	0.54	0.33	2.7	16/12/31	1.030	1.030	,,	,,	,,	,,
102	Dabinett ..	4/12/31	1.042	0.35	0.26	6.3	22/12/31	1.025	1.023	,,	,,	,,	,,

TABLE II.

Competition Ciders and Perries, 1931-32.

JUDGES' AWARDS.

Ciders.

Class 1.	*No.*	Kingston Black. (9 *Entries*).
First Prize ..	1	H. E. Dabinett, Somerton, Som.
Second Prize ..	3	G. Breakwell, Perthyre, Mon.
Third Prize ..	2	Major C. Jackson, Charlton Mackrell, Som.
Fourth Prize ..	7	W. Hill, Beardley, Kittisford, Som.
Reserve	4	E. T. Bryant, Leycroft, Taunton, Som.
Commended ..	5	J. Dennis & Sons, Churcham, Wor.
,, ..	9	T. J. Frampton, Barton St. David, Som.
,, ..	8	G. P. Hallett, Charlton Adam, Taunton, Som.
,, ..	6	W. R. Thomas, Nunnington, Her.

Class 2a.		Sharp Varieties. (Acidity 0.8% or above). (9 *Entries*).	*Variety.*
First Prize ..	16	S. F. J. Clarke, Honiton, Devon	Sour Cluster.
Second Prize ..	18	W. H. Hunt, Easton-in-Gordano, Som.	Hartisman.
Third Prize ..	13	S. J. Mullins, Dingestow, Mon.	Frederick.
Fourth Prize ..	12	W. Ludlow, Westbury-on-Trym, Glos.	Glo'ster Neverblight
Reserve	15	J. Walters & Sons, Newton St. Cyres, Devon	Winter Stubbets.
Commended ..	14	G. Breakwell, Perthyre, Mon.	Frederick.

Class 2b.		Medium Sharp Varieties. (Acidity below 0.8%). (10 *Entries*).	
First Prize ..	21	E. T. Bryant, Leycroft, Taunton, Som.	Langworthy.
Second Prize ..	19	G. Breakwell, Perthyre, Mon.	Breakwell's Seedling
Third Prize ..	25	W. J. Berry, Newton St.Cyres, Devon	Wyatt's Seedling.
Fourth Prize ..	22	E. T. Lewis, Dymock, Glos.	Norman.
Reserve	20	J. Walters & Sons, Newton St. Cyres, Devon	Langworthy.
Very Highly Com'ded	24	G. Williams & Son, Westhide, Her.	Sharp Apple.

Class 3.		Sweet Varieties. (13 *Entries*).	
First Prize ..	41	G. Breakwell, Perthyre, Mon.	Perthyres.
Second Prize ..	37	E. T. Bryant, Leycroft, Taunton, Som.	Woodbine.
Third Prize ..	33	W. J. Berry, Newton St. Cyres, Devon	Sweet Alford.

Class 3—*contd.*

Fourth Prize ..	39	E. T. Bryant, Leycroft, Taunton, Som.	Sheep's Nose.
Reserve	35	Major C. Jackson, Charlton Mackrell, Som.	White Jersey ?
Very Highly Com'ded	32	S. Cursons, Dunsford, Devon	Sweet Alford.
Highly Commended	31	H. Daniel, Honiton, Devon..	Sweet Alford.

Class 4. BITTERSWEET VARIETIES. (20 *Entries*).

First Prize ..	50	E. Edwards, Norton Canon, Hereford	Knotted Kernel.
Second Prize ..	48	F. Vincent, Pinhoe, Devon ..	Tremlett's Bitter.
Third Prize ..	42	W. H. Hunt, Easton-in-Gordano, Som.	Royal George.
Fourth Prize ..	53	S. J. Mullins, Dingestow, Mon.	French.
Reserve	58	H. E. Dabinett, Somerton, Som.	Royal Jersey.
Very Highly Com'ded	43	W. R. Thomas, Nunnington, Hereford	Cherry Norman.
Highly Commended	54	J. Baker, Bassaleg, Mon. ..	Chisel Jersey.
,, ,,	55	J. Baker, Bassaleg, Mon. ..	Dabinett.
,, ,,	45	S. R. Plumley, Barton St. David, Som.	Broadleaf Norman.
Commended ..	51	E. Edwards, Norton Canon, Hereford	Strawberry Norman.

Class 5. BLENDS. (28 *Entries*).

First Prize ..	62B	W. J. Berry, Newton St. Cyres, Devon.
Second Prize ..	64A	E. T. Bryant, Leycroft, Taunton, Som.
Third Prize ..	74B	W. R. Thomas, Nunnington, Hereford.
Fourth Prize ..	71A	Major C. Jackson, Charlton Mackrell, Som.
Reserve	66A	H. E. Dabinett, Somerton, Som.
Very Highly Com'ded	73B	S. R. Plumley, Barton St. David, Som.
Highly Commended	69B	W. Hill, Beardley, Kittisford, Som.
Commended ..	63B	G. Breakwell, Perthyre, Mon.

Class 6. PERRIES. (7 *Entries*).

First Prize ..	77	R. Evans, Norton Canon, Hereford	Blakeney Red.
Second Prize ..	76	R. C. G. Cotterell, Bridge Sollers, Hereford ..	Blakeney Red.
Third Prize ..	79	R. Hyett, Dymock, Glos. ..	Blakeney Red.
Fourth Prize ..	78	S. W. Mullins, Raglan, Mon.	Blakeney Red.
Reserve	80	J. P. Eley, Frampton Cotterell, Glos.	Eley's Nonsuch.
Commended ..	82	J. Jones, Dymock, Glos. ..	Pine.

VOLATILE ACIDITY IN CIDER.

A. THE ESTIMATION AND IDENTIFICATION OF VOLATILE ACIDS IN CIDER.

B. THE DEVELOPMENT OF VOLATILE ACIDITY IN BOTTLE AND CASK CIDERS.

By Vernon L. S. Charley.

Acetification is undoubtedly one of the most widespread and frequently occurring disorders of cider, the prevention of which is a matter of considerable importance to the cider-maker. Cider, a beverage of low alcoholic strength, is particularly prone to attack by Bacterium xylinum and other kinds of acetifying bacteria. In many cases acetic fermentation has commenced before the fruit is milled; for example, in cases where the fruit has been stored in heaps and allowed to deteriorate into an unsound condition. Cider made from such fruit would naturally be more or less acetified, the product finally obtained possessing a relatively high percentage of acetic acid and a correspondingly low alcohol content.

The problems of preventing acetic fermentation in ciders, and the amelioration of already acetified material have received much attention in the past. The position in regard to acetification was reviewed in 1913 in a paper by Barker and Grove (1), and the latter author later published the results of two series of investigations on this subject (2), (3). Part of the concluding paragraph of the last paper cited may be quoted here: "The practical conclusions to be drawn from this investigation are that acetic bacteria are invariably present in ciders made under ordinary conditions, and that acetification will occur during storage in cask at normal or high temperatures unless special precautions are taken. Of these the simplest appears to be to cover the surface of the liquor with a layer of liquid paraffin or a tasteless and odourless oil, at least $\frac{1}{4}$ inch thick. Slightly less efficient is the method of keeping the cider charged and covered with carbonic acid gas."

In very recent years the increase in popularity of cider has been responsible for a considerable modification of the type of beverage

demanded by the public. In large towns and cities the tendency amongst hotel and private purchasers is toward a sweet or medium sweet bottled cider of rather low alcoholic strength. For this class of trade, the presence of volatile acids in quantity above 0.2 per cent. in the cider is a distinct disadvantage. It is true that certain districts in the West of England have evinced a definite preference for cider with more than a trace of " hardness "—as acetification is colloquially termed—but there can be no doubt that the new class of cider consumer prefers a sweet drink free from any suspicion of vinegar flavour.

In view of these recent developments in the cider trade it has become important to study the question of the development of volatile acidity in ciders, with special reference to bottled products. In this connection it may be pointed out that the volatile acidity of cider is considered in granting the National Mark to any given brand of cider. No cider can be sold under the National Mark Scheme inaugurated by the Ministry of Agriculture and Fisheries for cider in 1930, if the volatile acidity is in excess of 0.20 per cent. This limiting percentage is of importance to all cider-makers for obvious reasons. It is necessary to realise that the particular figure of 0.20 per cent. which has been fixed is an index not only of the degree of acetification of the cider but also, to some degree, of the care taken in manufacture. The production of acetic acid in cider is dependent upon the access of air. The amount of care bestowed upon the condition and storage of the cider fruit and the making and storage of the cider is directly reflected in the amount of volatile acid developed. Hence, the volatile acidity of a cider enables to be formed some estimate, admittedly approximate, of the previous treatment of that particular sample.

The acetic acid content of ciders is not necessarily correlated with taste. It has been repeatedly observed that samples containing 0.25—0.3 per cent. of volatile acid may appear to the taste to be less acetic than ciders containing considerably lower amounts. Many factors are involved in this apparent paradox. Acetic acid is much more penetrating and conspicuous in a thin cider of low acidity than in a full-bodied, fairly acid beverage. Sugar may be relied upon to fulfil its well-known role of masking high acidity, and percentages of volatile acid well above the National Mark limit have been known to be practically unnoticeable to the taste on account of the sugar present. Consequently, it is difficult to form an accurate estimate of the volatile acidity by taste alone.

In view of the scarcity of quantitative data relating to this subject, and of the importance of obtaining some knowledge and understanding of it, the question of volatile acidity in bottled and draught

ciders was studied from various points of view during the 1931—32 season.

As it was necessary to work throughout on a quantitative analytical basis, it was important at the outset to select a method of analysis which would give consistent and accurate results. The actual programme of research was consequently divided into two sections—

(*a*) The estimation and identification of volatile acids.

(*b*) The development of volatile acidity in bottled and cask ciders.

In the first part of the present paper, therefore, an account is given of a comparative study of various methods for the estimation of volatile acidity in cider, together with the identification of the different acids included in the total volatile acidity. The experimental data for the development of volatile acidity in a variety of types of bottles are then presented, and the effects of storage temperature, nature of container and its position in the store, discussed. The increase in acetic acid in cask ciders under the normal conditions of factory routine is shewn, and the effect of ullage and cask linings on the rate of development illustrated by experimental data. Finally, the bearing of the results on commercial practice is indicated.

A. The Estimation and Identification of Volatile Acids.

(*a*) *The Estimation of Volatile Acidity.*

For several years the French official method (Duclaux) has been used in this Laboratory for the determination of volatile acidity. The method combines ease of manipulation with some degree of speed and is useful for this reason for multiple series of analyses. However, during 1931, it became necessary to use the tentative method adopted for use in National Mark cider analyses. At first serious discrepancies occurred between the two methods, but the causes were later discovered and remedied. The opportunity was also taken to examine various other methods and to compare their results. The methods chosen, together with a brief outline of the procedure adopted, will be enumerated here.

1. *English (tentative) method.*

This consists of the steam distillation of 50 cc. cider in a 200 cc. flask, proceeding until 200 cc. distillate are collected, and continuing to the point when a further 15 cc. of distillate require not more than

0.1 cc. $\frac{N}{10}$ caustic soda for its neutralisation. The titre of the distillate is obtained with soda, using phenol phthalein as indicator, and the acidity calculated as acetic acid. The chief difficulty is associated with a correct determination of the end-point; whilst other indicators were tried, phenol phthalein served as well as any. Two important precautions must be taken. Firstly, the water for the steam production must be boiled for at least 20 minutes before attaching the steam supply to the distillation flask. Secondly, the volume of liquid in the latter flask must be reduced to 25 cc. by the end of the estimation by means of a small flame.

Two modifications of the apparatus used for this method were tested. In the first, a splash bulb was inserted between the tube leading from the distilling flask to the condenser; any mechanical transference of cider from distillation to distillate vessels, occasioning an increase in titratable acidity in the latter, was thus minimised. The second modification was the use of the apparatus given in "Methods of Analysis of the Association of the Official Agricultural Chemists" (4). A larger flask, 500 cc. capacity, was used, and the usual slanting position for steam distillations was adopted, in contrast to the vertical form of apparatus utilised in the previous two cases.

2. *Duclaux method.*

A mixture of 20 cc. cider and 35 cc. water is distilled slowly into a 50 cc. graduated receiver. Exactly 50 cc. are collected and titrated. If "n" c.c.'s of $\frac{N}{10}$ soda are used,

$$\text{volatile acidity} = n \times \frac{3}{80} \text{ per cent.}$$

The method is quicker than steam distillation, and the somewhat indeterminate collection of 15 cc. portions in the latter procedure is obviated.

3. *Widmer's micro-method.*

This method has recently been introduced by Dr. Widmer, chemist at the Swiss Research Station at Wadenswil. The apparatus consists of a small Jena glass flask of 50 cc. capacity tapering to a narrow section at the lower end. The neck widens out to form a cylinder graduated at 3 and 7 cc. Communication between cylinder and flask can be prevented by means of a glass

tube with a widened ground end which fits tightly into the narrow neck. This tube leads from the flask to the condenser, a further ground glass joint serving as an attachment. A vessel, graduated at 10.5 cc. rests under the condenser outlet. Communication between the graduated cylinder and the lower flask may be achieved by gently raising the latter by which means the glass joint is loosened. 6 cc. of cider are run into the flask, boiling stone and 1 crystal of tartaric acid added, and 4.5 cc. are then distilled at a very slow rate. The flame is removed, and 3 cc. distilled water are pipetted into the cylinder and allowed to run into the flask. 3 cc. are now distilled over. A further 3 cc. water are run into the flask, and 3 cc. again distilled. The 10.5 cc. of distillate are titrated with $\frac{N}{100}$ caustic soda, using one drop of phenol phthalein as indicator. Using such small quantities it is essential that all parts of the apparatus should be scrupulously clean and free from grease. This method has the advantage in speed, 10 minutes only being needed for an estimation, compared with 30 minutes for the Duclaux method and $\frac{3}{4}$ to 1 hour for the steam distillation procedure.

The special apparatus for the determination by this method may be obtained from Kunz & Co., Glassblowers, Zurich, Switzerland.

The experiments were carried out on a series of synthetic solutions of various acids, in which the volatile acidity was accurately known, and also on ciders of various degrees of acetification. The results are presented in Table I.

TABLE I.

Comparison of Various Methods for Estimation of Volatile Acidity. (Results Calculated as Percentages of Acetic Acid.)

Experiment No.	Test Solution.	Tentative English Method.	English Method. Modification I.	English Method. Modification II.	French Official Method (Duclaux).	Swiss Method (Widmer).
1	0.0786% Acetic Acid	0.078	0.079	0.078	0.078	0.077
2	0.1037% Acetic Acid	0.103	0.104	0.102	0.100	0.099
3	0.210% Acetic Acid	0.208	0.210	0.207	0.200	0.202
4	0.4% Malic Acid	0.003	0.003	0.007	0.003	0.003
5	0.1% Tartaric Acid	0.003	0.005	0.006	0.004	0.003
6	0.100% Acetic Acid .. .. 0.1% Tartaric Acid .. .. 0.4% Malic Acid	0.107	0.105	0.110	0.099	0.100
7	0.200% Acetic Acid .. .. 0.1% Tartaric Acid .. .. 0.4% Malic Acid	0.199	0.196	0.198	0.190	0.209
8	Kingston Black Cider (one year old)	0.028	0.029	0.029	0.023	0.021
9	Frederick Cider (one year old) ..	0.023	0.023	0.023	0.022	0.019
10	Woodbine Cider (two years old) ..	0.037	0.031	0.035	0.028	0.025
11	Acetified Cider	0.291	0.290	0.284	0.279	0.274

A survey of these data shows that the English (tentative) method and the two modifications agree very closely. In every case where volatile acids were present, the English method gave higher results than the French procedure, although the differences were small, whilst in those experiments where the percentage of volatile acids was accurately known, *i.e.* Nos. 1, 2, 3, 6, 7, the English method approximated more nearly to the correct figures than the French. All determinations gave small figures for tartaric and malic acids (Nos. 4, 5), but the effect of these two non-volatile acids on the results when used in conjunction with some volatile acid solution was inconclusive (Nos. 6, 7). In practically all cases the micro-method afforded the lowest results of any of the methods, although again the divergence was not great. No evidence of any considerable differences between the English and French methods was noted. The discrepancies to which attention was drawn above were believed to be due to insufficient boiling of the water for the steam distillation. This point was tested, and widely differing figures were obtained by varying the preliminary time of boiling to remove all traces of carbon dioxide. It was also observed that a reduction of volume of the liquid in the distillation flask much in excess of 50 per cent. tended to give high results.

In view of the correspondence between the true figures and the results obtained with the English (tentative) method for Experiments No. 1, 2, 3, 6, 7 it was decided to use this method for all the analytical work undertaken in connection with this study.

(*b*) *Identification of Volatile Acids in Kingston Black Cider.*

The characteristic feature of acetification is the formation of acetic acid from the alcohol in the medium. But the fact that ripe apples possess a pleasant aroma, which is retained by the cider, suggested that other volatile acids besides acetic acid are also present. Power and Chesnut (5), investigating the odorous constituents of apples, found that in American fruit amyl esters of formic, acetic and caproic acids were present, together with very small amounts of amyl caprylate. No literature concerning the actual identity of the volatile acids in cider made from English apples has been published, and an attempt was consequently made to investigate the problem.

Two gallons of Kingston Black cider (volatile acidity 0.10 per cent.) were steam distilled for a long period until no further appreciable quantities of acid were collected. The distillate was strongly acid, and slightly turbid. The whole of the distillate, consisting of 10 litres, was made alkaline with barium hydroxide and evaporated to small volume. The excess barium was removed by filtration after precipitation as carbonate. The separation of

any volatile acids present was attempted by methods applied by Power and Chesnut in their study. The silver salts of the various acids in the homologous series commencing with formic acid may be separated by utilising their differing solubilities in water. A strong solution of silver nitrate was prepared of such a strength that the whole of the volatile acids present in the concentrated solution could be precipitated by about eight additions of 0.5 cc. each of nitrate.

In the actual separation it was found that the first two fractions became almost black after a short exposure to air, thus suggesting the presence of formic acid. It was necessary completely to remove the formic acid before proceeding to the separation of the other acids, and this was done by passing a slow current of CO_2 through the solution, and adding small amounts of potassium permanganate. The manganese dioxide precipitate was filtered off. An aliquot of the filtrate was then treated with successive portions of silver nitrate, the precipitate being filtered off after each addition. The salts were practically white and were washed with a minimum of water to remove any residual barium salt, and dried in a dessicator. Weighed portions of each fraction were then ignited to constant weight. The analyses of the fractions are contained in Table VII.

TABLE VII.

Fractional Precipitation of Silver Salts of Volatile Acids in Kingston Black Cider.

Fraction.	Weight of Ag. Salt.	Weight of Ag.	Per cent. Ag.	Per cent. Ag. calculated for various Acids.	
	gr.	gr.			
I	0.0437	0.0185	42.3	Silver caprylate	43.0
II	0.0290	0.0123	42.4	,, ,,	,,
III	0.0310	0.0148	47.8	Silver caproate	48.4
IV	0.0548	0.0266	48.6	,, ,,	,,
V	0.0311	0.0189	60.8	Silver acetate	64.6
VI	0.0300	0.0190	63.3	,, ,,	,,
VII	0.0148	0.0095	64.2	,, ,,	,,
VIII	0.0790	0.0510	64.5	,, ,,	,,

Comparison of the theoretical percentages of silver in the three acids shewn in the Table with those found experimentally affords evidence of the presence of caprylic, caproic and acetic acid. The presence of formic acid had been shown by the blackening of the first two fractions, together with specific tests for that acid. It is

probable that the low percentage of silver in Fractions I and II was due to the presence of small quantities of a higher homologue of caprylic acid. Fraction IV was nearly pure silver caproate, whilst the last two fractions were practically pure silver acetate. Acetic acid is shown to be the predominant volatile acid, but no evidence of the presence of valeric acid, the silver salt of which contains 51.7 per cent. of silver, was adduced.

B. The Development of Volatile Acidity in Bottled and Cask Ciders.

No published figures have been available dealing with the increase of acetic acid in bottled and draught ciders of varying ages and differing storage treatments. The experiments now to be described were designed to throw some light on the quantitative aspect of this problem. The investigation was directed towards possible correlation of the development of acetic acid with the following factors :—nature and size of bottle used, method of storage of bottle (horizontal or vertical), and storage temperature.

A pipe of juice from mixed apples was reserved for the experiment and fermentation was allowed to proceed until the specific gravity had fallen to 1.020, when the cider was filtered and bottled in screw stopper, champagne pint and quart, and crown corked bottles respectively. The scope of the experiment was extended by storing half the bottles of each kind in a cellar where the average temperature was 45°F., whilst the rest were kept in the laboratory where the temperatures showed considerable fluctuations and were substantially higher than in the cellar.

In each store, half the bottles were laid on their sides and the remainder placed in an upright position. The ciders were analysed after storage in bottle for 3, 7 and 11 months respectively.

A similar sample of cider was allowed to ferment to a gravity of 1.004, and after filtration screw stopper and champagne pint and quart bottles were filled and corked. This series of bottles was treated exactly as the medium sweet bottled cider, and was analysed at corresponding intervals. The analyses of the fresh juice and two ciders used for the tests are given below :—

	Specific Gravity.	Acidity (as Malic Acid).	Tannin.	Alcohol (by weight)	Volatile Acidity.
Fresh juice ..	1.047	0.52%	0.22%	—	0.017%
Medium Sweet Cider ..	1.020	0.53%	0.21%	2.9%	0.021%
Dry Cider ..	1.004	0.53%	0.21%	4.5%	0.031%

The results from the two series of experiments are given in Tables II and III.

TABLE II.

DEVELOPMENT OF VOLATILE ACIDITY IN MEDIUM SWEET CIDER BOTTLED IN VARIOUS TYPES OF BOTTLES. (RESULTS CALCULATED AS PERCENTAGES OF ACETIC ACID.)

Type of Bottle.	Position of bottle in store.	Laboratory Storage.			Cellar Storage.		
		3 Months in bottle.	7 Months in bottle.	11 Months in bottle.	3 Months in bottle.	7 Months in bottle.	11 Months in bottle.
Screw Stopper	Horizontal	0.049	0.102	0.114	0.023	0.025	0.041
	Vertical	0.043	0.116	0.129	0.024	0.036	0.049
Champagne Pint	Horizontal	0.031	0.050	0.091	0.023	0.024	0.034
	Vertical	0.023	0.052	0.094	0.023	0.025	0.037
Champagne Quart	Horizontal	0.019	0.045	0.099	0.023	0.024	0.037
	Vertical	0.021	0.068	0.101	0.026	0.029	0.042
Crown Cork A*..	Horizontal	0.053	0.103	0.194	0.023	0.031	0.044
	Vertical	0.054	0.100	0.198	0.024	0.038	0.059
Crown Cork B*	Horizontal	0.049	0.100	0.199	0.031	0.029	0.051
	Vertical	0.060	0.078	0.201	0.034	0.034	0.059

* A=Best quality cork.
B=Second quality cork.

TABLE III.

Development of Volatile Acidity in Dry Cider Bottled in Various Types of Bottles. (Results Calculated as Percentages of Acetic Acid.)

Type of Bottle.	Position of bottle in store.	Laboratory Storage.			Cellar Storage.		
		3 Months in bottle.	7 Months in bottle.	11 Months in bottle.	3 Months in bottle.	7 Months in bottle.	11 Months in bottle.
Screw Stopper	Horizontal	0.079	0.117	0.133	0.044	0.049	0.069
	Vertical	0.084	0.118	0.135	0.044	0.051	0.072
Champagne Pint	Horizontal	0.065	0.099	0.107	0.039	0.040	0.043
	Vertical	0.065	0.102	0.110	0.031	0.049	0.050
Champagne Quart	Horizontal	0.061	0.100	0.110	0.035	0.042	0.049
	Vertical	0.062	0.101	0.119	0.037	0.047	0.054

In considering the data contained in Tables II and III, it is important to note that every precaution was taken to ensure efficient corking of the bottles. Several cases were noted where a slight and almost unnoticeable ridge had been grooved in the cork by some foreign material in the corking machine, leading to access of air and inevitable acetification at an enhanced rate. Such bottles were excluded from those used for analytical work. To minimise experimental error, three bottles were analysed in each section, and duplicate determinations were carried out on each bottle. The figures given in the Tables are the averages of the six results so obtained.

The Tables show certain well defined differences between the developments of volatile acidity in the various types of bottles. Cider in crown cork bottles showed the greatest development of acetic acid in the medium sweet series, although there was no significant difference between the action of the two qualities of corks. In all cases, the screw stopper bottles were superior to the crown corked bottles. The least development of volatile acidity was shown by the cider bottled in the champagne type of container. These divergences are accentuated in the case of storage in the fluctuating temperature store (designed to reproduce storage under domestic conditions). From the point of view of storage of cider in bottle for considerable periods, it would appear that champagne bottles are indispensable whilst, on the contrary, screw stopper and crown cork bottles are not satisfactory.

Turning to the effect of the position of the bottle during storage, the figures all suggest that the development of volatile acids is retarded by lying the bottles on their sides. The effect of this treatment is to keep the corks moist and swollen, thus maintaining an air-tight closure of the bottle.

The effect of storage temperature is most conspicuous. In the medium sweet cider series, the volatile acidity of ciders stored at the higher temperature was in all cases (at the 11 months storage period) from three to four times greater than in similar samples maintained at the lower temperature. The crown corks appeared to be particularly vulnerable to the effect of temperature. In the case of Crown cork B (the bottle being stored horizontally) the volatile acidity had increased from 0.049 per cent. after 3 months to 0.199 per cent. after 11 months in bottle. This latter figure is very near to the National Mark limit of 0.2 per cent. The cider possessed an acetic acid content of only 0.021 per cent. when bottled, which is certainly well below the figure generally obtained with cask cider stored for bottling purposes. With a more normal percentage of volatile acidity in the cider at the time of bottling,

it would appear that the National Mark limit, under the above conditions of storage, would be exceeded.

The champagne pint and quart bottles were considerably more resistant to the effect of temperature, whilst the screw-stopper containers showed increases in acetic acid second only to the crown cork bottles. At the cellar temperature all classes of bottles showed only slight increases in volatile acidity.

The higher figures obtained in the dry cider series are partly due to the greater percentage of volatile acidity in the cider when bottled. There is evidence that the development in both cellar storage and storage at higher temperatures is retarded in the dry cider, as compared with the medium sweet cider. This effect is probably due to the higher percentage of alcohol in the former. The activity of the common acetic bacterium, *B. xylinum*, is inversely proportional to the alcohol content ; in media containing 6—8 per cent. or more of alcohol acetification is almost completely inhibited, but with lower percentages of alcohol the resistance to the bacterial action lessens as the alcohol decreases. Consequently it may be stated that beverages containing from 2.5 to 3.5 per cent. of alcohol will, other conditions being similar, develop acetic acid more rapidly than those with higher alcoholic contents.

Certain general conclusions can be drawn from the above. In the first place, it is definitely established that for storage of cider in bottle for long periods at fluctuating or high temperatures, champagne bottles should be used. For all classes of trade where it is expected that the bottled cider will be exposed to the vagaries of domestic routine, or for export to tropical or semi-tropical countries, the same type of bottle should be chosen. The screw stopper and crown cork type of bottle are excellent for short storage work, for which, indeed, they are now widely used. Secondly, the cooler the storage temperature of the cider, the slower will be the development of acetic acid. Especially during hot summer weather, a few degrees difference in temperature will considerably affect acetification. Thirdly, the horizontal position is advisable for all bottles that have to be stored for any length of time, especially if the alcohol content of the cider is low.

The Development of Volatile Acidity in Draught Ciders.

The data presented in Tables II and III have shewn the increase in volatile acidity that may be expected in ciders bottled under the conditions of these experiments. The primary concern in obtaining a low volatile acid content in bottled cider should thus be to check the growth of acetic acid bacteria in the cider when it is stored in

casks preparatory to the bottling. During the summer, when temperatures are relatively high, considerable increases in acetic acid may be expected in the cider in bulk. The quantitative study of this point was complicated by the divergences between one cask and another, but the following data show the increase in volatile acidity that may be normally expected.

A series of 120 gallon casks were filled with fresh juice (volatile acidity 0.041 per cent.) in November 1931, and analysed at fortnightly intervals until filtration in January 1932. At this point, the volatile acidities of eight of the ciders were 0.091 per cent., 0.085 per cent., 0.102 per cent., 0.065 per cent., 0.131 per cent., 0.077 per cent., 0.079 per cent., 0.099 per cent. The juice was filtered, mixed, and pumped into a series of carefully cleaned casks, which were bunged down with special tapering bungs covered with flannel and paraffin wax. The volatile acidity of the bulk of filtered cider was 0.086 per cent. In July 1932, *i.e.* when the filtered cider had been in cask six months, the volatile acids were again estimated. Eight casks of cider afforded the following percentages: 0.141 per cent., 0.190 per cent., 0.116 per cent., 0.110 per cent., 0.133 per cent., 0.191 per cent., 0.122 per cent., 0.101 per cent. Detailed data in connection with all the above will not be given, but figures showing the rate of development of volatile acidity in four of the casks previous and subsequent to filtration are presented in Tables IV and V.

TABLE IV.

Development of Volatile Acidity in Four Casks of Fermenting Cider. (Figures Given as Percentages of Acetic Acid.)

Date.	Cask 1.	Cask 2.	Cask 3.	Cask 4.
November 1st, 1931	0.041	0.041	0.041	0.041
November 14th, 1931	0.046	0.050	0.043	0.045
December 1st, 1931	0.059	0.084	0.049	0.049
December 14th, 1931	0.071	0.099	0.052	0.052
January 1st, 1932	0.082	0.113	0.055	0.061
January 14th, 1932 (cider filtered)	0.091	0.131	0.065	0.079

TABLE V.

Development of Volatile Acidity in Four Casks of Filtered Cider. (Figures Given as Percentages of Acetic Acid.)

Date.	Cask A.	Cask B.	Cask C.	Cask D.
February 1st, 1932	0.086	0.086	0.086	0.086
February 14th, 1932	0.090	0.093	0.089	0.087
March 1st, 1932	0.099	0.103	0.093	0.087
March 14th, 1932	0.107	0.107	0.099	0.091
April 1st, 1932	0.121	0.116	0.105	0.093
April 14th, 1932	0.129	0.131	0.110	0.094
May 1st, 1932	0.133	0.138	0.117	0.095
May 14th, 1932	0.139	0.142	0.123	0.095
June 1st, 1932	0.149	0.157	0.125	0.097
June 14th, 1932	0.162	0.169	0.135	0.099
July 1st, 1932	0.181	0.179	0.139	0.100
July 14th, 1932	0.191	0.190	0.141	0.101

Examination of Tables IV and V reveals considerable differences between the developments of volatile acids in respective casks. The barrels were taken from the stock of 120 gallon " pipes " used in the normal routine work of the Institute, and no attempt was made to select special casks. No flaws were obvious in any of the casks, and it may be assumed that the eight used in the experiment were representative of the type of vessels in general use for cider making. In view of this assumption the figures presented above for volatile acidities of the cider in the eight various casks may be taken as being reasonably true for the majority of ciders stored under similar conditions. Obviously, efficient cooperage and continual care of the casks will tend to minimise the increase of acetic acid, whilst on the other hand failure to take such precautions as using sound bungs and adopting the principle of regular filling up of casks to prevent ullage will inevitably lead to the production of hard cider.

It is thus of importance fully to recognise and appreciate the desirability of suitable storage vessels for cider designed for the

bottle trade, especially when such storage extends into the summer and early autumn months. In this connection, two further experiments, which are discussed in the following section, were arranged to examine :

(*a*) the effect of ullage,
(*b*) the effect of cask linings.

(*a*) *The Effect of Ullage on the Development of Volatile Acidity in Cask Cider.*

The practice of filling up casks of cider at regular intervals to prevent the drying out of the top staves has been carried out for many years, but no quantitative data have appeared to demonstrate the efficacy of such procedure. For this reason, the effect of ullage was tested by filling two 10 gallon casks with the same cider, allowing one cask after being tightly bunged down to remain untouched whilst the other was filled up at weekly intervals. Analyses were carried out fortnightly and the results are given in Table VI.

The experiment was commenced in November, 1931, and finished in June, 1932. The figures indicate that the prevention of ullage in casks of all sizes is of great importance in retarding the increase in volatile acidity. The effect of ullage would be correlated to a great extent with the temperature of the store. In the above experiment, the casks were stored between 40—50°F. Lower temperatures would tend to minimise, and higher temperatures to accentuate, this effect.

(*b*) *The Effect of an Enamel Preparation on the Rate of Acetification in Casks.*

Cask enamels and varnishes have been on the market for many years for application to the inside or outside of casks to provide airtight surfaces. During the 1931—32 season some trials were carried out with an acid-resisting enamel which sets on the inside of the cask producing a hard glossy surface. Two series of trials were arranged. In the first, three new 10-gallon casks were treated with the enamel. The procedure of application is of the utmost importance, the efficiency of action depending on the production of a smooth, continuous surface. The heads of the casks were removed and the inner surface of each thoroughly dried by means of a small brazier burning charcoal or oak shavings. The enamel was then applied with a brush and left to harden, care being taken that efficient joints were made when the head was returned to its position. The casks were then filled with water and allowed to

TABLE VI.

DEVELOPMENT OF VOLATILE ACIDITY IN CASKS WITH AND WITHOUT ULLAGE. (RESULTS SHOWN AS PERCENTAGES OF ACETIC ACID.)

	Nov. 1 1931	Nov. 14 1931	Dec. 1 1931	Dec. 14 1931	Jan. 1 1932	Jan. 14 1932	Feb. 1 1932	Feb. 14 1932	Mar. 1 1932	Mar. 14z 1932	Apl. 1 1932	Apl. 14z 1932	May 1 1932	May 14 1932	June 14 1932
Filled cask	0.031	0.033	0.037	0.042	0.051	0.057	0.069	0.074	0.084	0.089	0.094	0.099	0.112	0.120	0.135
Unfilled cask	0.031	0.033	0.038	0.045	0.057	0.083	0.112	0.163	0.184	0.235	0.289	0.331	0.359	0.383	0.429

soak for 24 hours, when the water was removed. The soaking process was twice repeated, which treatment was calculated to remove all traces of flavour attributable to the enamel. The three casks were then filled with cider, and a control was arranged by filling some screw stopper bottles and keeping these at 32°F. The casks were stored in a cellar where a steady temperature of about 45°F. was maintained; no attempt was made to make good any loss of cider by evaporation. The experiment proceeded during the months of May, June and July, 1932. The volatile acidity of the cider when placed in the casks was 0.040 per cent., and after two months in cask the following data were obtained :—

Cask No.	1	2	3
Volatile acidity ..	0.039%	0.043%	0.044%

There were slight increases in acetic acid in two of the casks, whilst the third was practically unchanged. The ciders were tasted, and no foreign flavour or taint could be detected, whilst the surface of the enamel was unimpaired.

A further trial was made with casks of 10 gallons capacity which had been in use under commercial conditions for a considerable period. It is inevitable that the inner surface of an old cask, or of a cask made from previously used staves, should be characterised by irregularities, all of which must be filled with the enamel before the final application is made. A direct comparison between treated and untreated casks was arranged. The casks were stored during the late summer and early autumn and were subjected to considerably higher temperatures than the first series. The temperature was fluctuating, and on several occasions 70°F. was reached. The initial volatile acidity of the cider used for the experiment was 0.097 per cent. Two months after filling the casks the figures were as follows :—

Treated Cask 1	*Treated Cask* 2	*Treated Cask* 3
0.111%	0.109%	0.110%

Treated Cask 4	*Untreated Cask*
0.101%	0.179%

The direct comparison between treated and untreated casks shows very distinctly the beneficial effect obtained by the use of an efficient enamel. A very careful comparison of the ciders was made by tasting. In the treated casks, it was impossible to detect any foreign flavour, and the difference between the volatile acidities of the treated and untreated casks was quickly observed by taste. A feature of the experiments which is of practical importance is the fact that in the treated casks no appreciable evaporation had occurred. The casks were completely full at the end of the storage period, whilst the untreated cask had developed approximately

half a gallon of ullage. The effective nature of the lining is amply demonstrated by these observations.

The approximate cost for material to treat casks varies with their condition, but with average barrels the cost is 4d. per 18 gallon cask, and pro rata for smaller or larger vessels.

Summary.

1. Various methods for the analysis of volatile acidity in cider are described and their results compared. The English method is shown to be the most accurate of those considered.

2. The development of volatile acidity in cider bottled under various conditions is discussed. The experiments show that for long periods of storage at moderate or high temperatures, screw stopper and crown cork bottles are unsuitable, whilst the champagne type of bottle is very satisfactory.

The effect of high temperatures is to increase the rate of development of volatile acidity very considerably.

Where possible, bottles should all be stored in a horizontal position.

Development of acetic acid is somewhat retarded in ciders with a higher percentage of alcohol.

3. The increase of volatile acidity in cask ciders is discussed, and data are presented to show the importance of keeping the casks as air-tight as possible. Various methods of achieving this are demonstrated by experiments concerning the effect of ullage and cask linings, both of which are shown to affect the cider to a marked degree.

4. The volatile acids present in a Kingston Black cider have been identified as mainly acetic acid with smaller quantities of caprylic, caproic and formic acids. No evidence of the presence of valeric acid was found.

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INVESTIGATIONS ON FRUIT PRODUCTS.

I.—PREPARATION OF JUICES, SYRUPS, CONCENTRATES, AND WINES FROM SOME ENGLISH FRUITS.

By Vernon L. S. Charley.

The recent developments in packing and grading of fruits have brought with them a series of problems of sufficient importance to demand close and detailed investigation both from the economic and practical points of view. Prominent among these problems is the utilisation of low quality fruit. A certain proportion of fresh fruits is always unsaleable on account of size or condition and, especially in the case of large growers, associations of growers, or even the larger markets themselves, it is impossible completely to disregard this portion of the crop from a revenue standpoint. That an alteration in the proportion of high grade to low grade fruit being grown is gradually being effected as a result of the more general adoption of modern methods of culture, is indisputable. But it can be equally emphasised that the disposal of the available "cull" material will remain a problem of importance for many years, unless new methods of utilisation are discovered and fresh outlets found.

At the present time, a considerable proportion of the fresh fruit crop is used for the preparation of a variety of products. Two different categories of products are at once distinguishable. In the first, the fruit crop is grown with the specific purpose of supplying the demands of the manufacturers of the products (*i.e.* jam), whilst in the second class the grower supplies the manufacturer only with such quantities of fruit as cannot be absorbed by the fresh fruit consumers. It is becoming more and more essential to discover new products to absorb this latter class of fruits, and afford some further degree of remuneration to the grower.

Prominent among the various methods suggested for dealing with fruit unsuitable for the market, are the manufacture of fruit syrups, concentrates and wines. The two former types of products have acquired widespread popularity in America. Citrus juices

initially became of importance, but were followed by syrups from various berry crops, and the products industry now provides an appreciable and steady outlet to the grower.

The production of pure fruit syrups commercially in this country has been of little or no account hitherto : the present series of papers is designed to demonstrate the possibilities of such products. Concentrates are not yet in use to an appreciable extent, except in the case of the apple. Fruit wines (alcoholic) have been made for a great many years in England on a domestic scale. Indeed, Worlidge, in his " Vinetum Brittanicum " published in 1678, gives details for the preparation of wines from various common fruits, together with descriptions of the products. There is undoubtedly a large quantity of home-made wines prepared in this country but their manufacture is not based on scientific principles, with the result that the quality of the products is very variable.

Brief references will be made here to the three classes of products mentioned above.

Fruit Syrups.

The Scandinavian countries of Europe consume large amounts of fruit syrups in the form of jellies (by addition of flour), as a sauce for puddings (*cf.* treacle or custard in this country), as a " sweet soup " (for children) and as a health food by cooking cereals such as barley, sago and rice with water and mixing with syrup. In Germany and Russia the production of syrups was formerly a domestic concern, but the tendency has been, in late years, for the manufacture to become commercialised, and this has resulted in the formation of a new industry to meet the demands. Whilst at first it was commonly supposed that this increasing demand for fruit syrups would be temporary and merely coincident with the period characterised by the wave of health movements which swept across Western Europe, this has proved incorrect and the use of such products has now become a settled and permanent addition to the national dietaries.

The vitamin content of fruit juices constitutes an important feature of their health-giving properties. Many fruits have now been examined and biological determinations of the various vitamins have been carried out. The most prominent accessory food factor is undoubtedly vitamin C, which is essential for the prevention of scurvy and is consequently of great importance in the average normal diet. The following fruits are good sources of vitamin C :— apples, blackberries, currants, plums, raspberries, strawberries and tomatoes. Pears contain vitamin C, but only in small quantities. Vitamin A, which is necessary for growth and a number of allied

physiological processes, is present in apples and strawberries in small quantities: tomatoes are a very good source of supply for this vitamin.

The stability of vitamin C is dependent on the absence of oxidising agents or air, and the conditions of acidity or alkalinity of the medium affect the deterioration of the vitamin to a marked degree. The effect of methods of preparation of fruit syrups on the stability of the vitamins is of vital importance. From the published literature it would appear that vitamin C is not affected by moderate heat treatment (*cf.* canned apples, strawberries and tomatoes); but the effect of aeration on both vitamins C and A would appear to be worthy of investigation in connection with the preparation of fruit syrups.

With regard to other vitamins, the only fruit which are concerned are the apple and tomato, both of which contain vitamins B_1, B_2, and B (water-soluble), but in no appreciable quantities.

There is wide scope for originality in the use of fruit syrups. Ice cream may be flavoured either by addition of syrup to the basic mix before freezing, or merely by pouring the syrup over a plain ice. With comparative ease, refreshing water ices may be produced. But undoubtedly the most promising use for fruit syrups is the manufacture of non-alcoholic beverages. Two practical considerations at once arise. In the first place, whenever a pure fruit juice is placed on the market, it has to face severe competition from mineral water products. Such materials are made almost exclusively from synthetic essences, colourings, and water, and cannot compare with pure fruit juices for health-giving properties. The question of cost is naturally intimately associated with the consideration of marketing, but sufficient data are not available at this stage of the fruit products studies to allow of a definite pronouncement being made. However, it is fairly certain that fruit juice beverages will cost a little more than similar mineral water drinks, but this extra cost will be small compared with the increased food value of the pure fruit beverage. It would seem that education of the public to the advantages shown by these products is a necessary preliminary to their widespread acceptance as beverages. In this connection, it is interesting to note that the tendencies in this country are towards drinks of a low or non-alcoholic nature, and this, in addition to the publicity attaching to the "Eat More Fruit" campaigns and "New Health Societies," should ensure a favourable predisposition of the consuming public to such products as are now under discussion.

The second point is that of supply of material. It is evident

that for a product to gain widespread favour sufficient material must be available year after year to satisfy the demand. It is difficult to arrive at even an approximate estimate of the amount of fruit available annually for the products, but the total amount must be quite considerable. With apples the problem is acute in some districts, for there is a limit to the quantities that can be used by cider-makers for blending with their vintage varieties. The fruit which remains as an unmarketable surplus when occasional glut crops of any particular variety are obtained could be utilised to a large degree for such products as are now under consideration. In such years of excessive crops the wastage becomes considerable and many tons of fruit do not pay for the costs involved in picking and transport whereas, converted into stable products capable of extended periods of storage without deterioration, some profitable return may reasonably be expected. The investigation of the problems of supplies of materials and the ultimate cost of the products is being actively pursued.

The literature on the subject hitherto has been mainly American. Brief reference will be made to its salient features. (Apple juice will not be discussed here. Full details on the production of non-alcoholic apple juice are given in Part III of this series, Investigations on Fruit Products in this Report, p. 214.)

Gore (1) studied the methods of production of various fruit juices and their storage conditions. No syrups were made.

Several papers have appeared from the Fruit Products Department of the College of Agriculture, Berkeley, attached to the University of California. Irish and Cruess (2, 3) recommend the preparation of a 45° Balling (45 per cent. sugar) syrup ; in such products it was notable that the colour and flavour remained unimpaired indefinitely, whereas fresh fruit juices, unsweetened, quickly deteriorated in both these respects. The production of beverages from such syrups, and the carbonation and preservation of these drinks are also discussed. Loganberry juice was shown to be easy to prepare, and the final product was characteristic for its excellent colour, flavour, and appearance. Sterilisation of the syrups is effected by heat (150°C for $\frac{1}{2}$ hour for carbonated beverages and 170°F for still liquors). Mention is made of the efficiency of the Seitz-sterilising filter with its germ-proof asbestos plates as an alternative to heat treatment for sterilisation.

Barker and Grove (4) in 1923 published the results of experiments directed toward the production of a number of cold process products. Included amongst these was a series of fruit juices. Favourable comments were passed on the nature of the products, which were

made from loganberries, raspberries, blackberries and black currants. The concentrated syrups (62-65 per cent. sugar) kept their flavour and colour for two years, and no signs of deterioration were noticed.

Appleyard and Hirst (5) in 1926 repeated the work on syrups on a much larger scale. Excellent syrups were made from black currant, raspberry, loganberry and red currant fruits, the last-mentioned being perhaps the most satisfactory.

Fruit Concentrates.

The preservation of fruit juice by concentration was studied at Long Ashton during the war, and large quantities of apple jelly were produced (6, 7). No record of concentration of fruit juices in general in this country is available. Overseas the subject has been studied by Irish (8) and various methods of preparation are discussed, the most satisfactory being the removal of water by freezing and centrifuging, whilst the most practical was vacuum distillation. The concentrates from berries were not considered to make beverages equal in quality to those prepared from fresh fruit syrups, but the drinks had distinct market possibilities. To quote the final paragraph of his summary, Irish claims, " Experiments and observations indicate that the preparation of fruit concentrates may provide an outlet for much of the State's surplus fruit."

Grove (9) gave the results of a series of experiments devised to obtain various products from the progressive concentration of apple juice. Various methods of preparation are shewn, and the character of the products discussed.

Fruit Wines.

The literature of fruit wines is chiefly confined to the publications from German Research Stations, and the fullest information of modern practice in the preparation of alcoholic products from fruit and berry crops is contained in a recent publication " Obst-und Beerenweine " (10). Many types of wine are on the market, the most common being heavy dessert wines containing 9—12 per cent. alcohol (by weight) and light dry table wines with alcoholic content of about 8 per cent. Very wide variations are found in the sugar percentages of fruit wines made in Germany, the percentages varying between 18 per cent. for strawberry sweet wine (specific gravity 1.060) and 2.5—0.08 per cent. for dry types of wine.

The inter-relation of sugar and acidity has a very direct bearing on the final composition of the wine. Very high percentages of fruit acids are encountered in the common berry fruits, and whilst

the difficulties caused by this marked acidity are minimised to a considerable extent by a large dilution of juice with water previous to fermentation, the degree of acidity remaining after such dilution and fermentation is in some cases sufficiently high to render the addition of sugar necessary. Particularly is this the case with red currant and raspberry products.

The production of fruit wines in this country has been so far almost entirely a domestic problem. However, it is certain that the quantities of such products made in the agricultural districts are of considerable magnitude. Agricultural workers make appreciable quantities of wines from surplus fruit crops and judging experience at the various Shows and Women's Institute Classes has revealed a remarkable number of high-class products. As some kind of indication of the extent of such wine-making, it may be of interest to give details of the amounts of wines made by the occupants of a row of 22 adjacent cottages in the heart of a purely agricultural district. The wines were made from surplus fruit grown in each cottager's own garden and were prepared in many cases with homely materials and by rule of thumb methods. Taking the cottages in order, the following number of gallons of wine were prepared in one season: $4\frac{1}{2}$, —, 9, $4\frac{1}{2}$, 2, —, 6, —, 9, 9, $4\frac{1}{2}$, $4\frac{1}{2}$, 9, 9, 9, 9, —, $4\frac{1}{2}$, —, —, $4\frac{1}{2}$, 6. The materials used in these cases were carrots, parsnips, red currants, gooseberries, blackberries, plums, elderberries, rhubarb, potatoes, green grapes, beet and the flowers of the dandelion and cowslip. Obviously no statistical value attaches to these data, except in so far as they point to the prevalence of such products among the agricultural working class.

The methods used were often crude and failures correspondingly frequent. Fermentation was, until quite recently, started by floating toast covered with a layer of brewer's yeast on the surface of the freshly expressed juice, and the addition of a variety of products to produce a highly flavoured wine lead to the use of such divergent materials as meat, raisins, sugar candy, rum and other spirits. But amongst this widespread production of more or less inferior decoctions has been a considerable quantity of high-class wines, prepared with care and according to formulae handed down as family traditions, and it is to these products that the fame of English home-made wines is entirely due. With more care in the making process and attention to details of storage it is possible that the use of soft fruit for wines could be considerably extended, and with a view to investigating the possibility of utilising such fruit on a commercial scale, as well as improving the methods for domestic application, the experiments reported later in this paper were commenced.

Experimental.

A comprehensive scheme of research was commenced in 1932 at Long Ashton with a view of studying the various problems of surplus fruit and its utilisation. During the 1932 fruit season syrups, concentrates and wines were prepared from a number of soft fruits, details of the methods and quantities used being given later. In the case of syrups and concentrates, the remarks are confined solely to their manufacture and present condition. Further experimental work is in progress to determine the different ways of using these products. Referring to the section on wines, a period for maturing in cask is essential for the wine to attain its full bouquet and flavour, and small casks of most of the samples have been set aside for this purpose. The remarks on the quality of the wines are based on observations made in March 1933.

Equipment and General Technique.

The fruits were milled in a small hand-worked grater mill, and the pulp collected and built up on a small press in a miniature set of racks and cloths after the fashion of a modern " cheese " of apple pomace in cider making. Pressure was applied by a small hydraulic pump, easily worked by hand and capable of giving very high pressures. Good yields of juice were obtained from most fruits when using this combined mill and press. The juices were strained (when possible) through a coarse cotton cider cloth followed by a layer of single or double muslin.

For filtration, a small wine filter was used. The principle is identical with that of cider filters, and the usual paper pulp was packed tightly into the filter. For some syrups needing sterilisation, a laboratory Seitz filter (capacity $\frac{1}{2}$ gallon) was found to be very satisfactory.

Preparation of Fresh Juices.

1. *Green Gooseberry.* 1 cwt. of green gooseberries was milled on 24 7/32 and the pulped fruit mixed with $4\frac{1}{2}$ gallons of water and 4 lbs. sugar. The water added was just sufficient to cover the solid material. A small quantity of Portugese wine yeast was added and the mixture left in a cool room. Three days later appreciable fermentation had commenced, and the juice was obtained by pressing. The juice separated easily and 13 gallons (specific gravity 1.028) were collected and used for 3 types of wine.

2. *Rhubarb.* Two series of juices were prepared in order that comparison might be made between wines made from juices

obtained either by milling the rhubarb or by soaking the sticks in a solution of sugar in water.

In the first case, 66 lbs. rhubarb were milled as fine as possible, $7\frac{1}{2}$ gallons water and 22 lbs. sugar added, and the whole mass allowed to ferment for 10 days, when the juice was obtained by hydraulic pressure. Sweet and dry wines were prepared. A further 66 lbs. of rhubarb were cut into short sticks about 6 inches long, and covered with the same quantity of sugar and water as in the first experiment. After 10 days, fermentation was in active progress, but the sticks still retained their shape, and the juice, which was only slightly thickened by diffusion from the sticks, was decanted, and the 9 gallons so obtained were fermented to sweet and dry types of wine.

The whole sticks were then milled and pressed, and 4 gallons of juice (rich pink in colour) were collected and fermented.

3. *Strawberry.* $3\frac{1}{4}$ cwts. of berries (jam quality fruit) were hulled and milled on 1/7/32. The pulp was mixed in barrels with 24 lbs. sugar, and well pounded to complete the maceration. A fair amount of fermentation ensued, and on 7/7/32 the pulp was pressed. The juice was obtained with ease but the residue, owing to its slimy nature, retained a considerable quantity of liquor. $26\frac{1}{2}$ gallons of juice were collected and strained clear from solid particles by cotton cloth and double muslin. Filtration of this juice through a small pulp filter was found to be impossible, the filter becoming completely choked up after the passage of 3 gallons of juice. 3 ozs. of D.R. pectinol and 3 tablets of potassium metabisulphite were added, the latter on account of the high temperatures prevailing which rendered excessive fermentation probable. After 24 hours, top and bottom deposits had formed and, whilst the middle portion was still cloudy, filtration was much easier and a clear juice obtained. This was used for the production of syrups, concentrates and wines.

The residue from the first pressing was well macerated with 10 lbs. sugar and 6 gallons of water and allowed to remain for 3 days. 11 gallons of juice (specific gravity 1.040) were obtained and fermented.

4. *Red Currant.* 196 lbs. of good quality fruit were pulped in a large cask on 16/7/32 and 10 lbs. sugar intimately mixed into the pulp. Some slight fermentation occurred in 48 hours, when the juice was recovered by pressure. $11\frac{3}{4}$ gallons were obtained without difficulty, partially cleared by cotton cloth, and, with difficulty, through muslin. It was impossible to filter even a

small quantity of the juice through the usual type of filter, and the pectinol treatment was again tried. 11 ozs. of 29-A pectinol were mixed into the juice and left for 1 day. Filtration was easier, and the juice was cleared with some difficulty. This juice was made into syrups (hot and cold processes).

The press residue was re-ground and macerated with 4 gallons water and 10 lbs. sugar, and left for 3 days. After pressing, the juice was mixed with a small quantity of unfiltered juice from the pectinol treatment, and fermented.

A further quantity of 120 lbs. of red currants was milled and pressed on 27 7 32 and the $7\frac{1}{2}$ gallons juice so obtained were fortified and sweet and dry wines prepared.

5. *Raspberry.* $1\frac{1}{2}$ cwts. of Baumforth A (jam quality) fruit were broken up in a cask with 1 lb. sugar, and a small quantity of yeast added. Eight days elapsed before any considerable fermentation commenced, and on 28 7 32 the pulp was pressed ; $10\frac{1}{2}$ gallons of juice were obtained which, after fortifying with sugar, were fermented into a sweet and dry wine. A further quantity of $1\frac{1}{2}$ cwts. of fruit was pressed immediately on arrival, and $12\frac{1}{4}$ gallons of juice obtained (yield, 71 per cent.). 250 grs. of pectinol were added on account of the difficulty in filtering the juice, and 48 hours later a copious deposit had settled and the juice was filtered to a brilliant condition by passing twice through the filter. This juice was converted into syrups.

6. *Black Currant.* This fruit presented the greatest difficulties in the preparation of the juice. 3 cwts. 14 lbs. of berries were received in good condition, and were milled on 26 7 32. The application of even slight pressure resulted immediately in the rupture of the press cloths. The pulp was exceedingly thick and slimy, but slowly underwent a remarkable change after 2 gallons of water and 3 lbs. sugar had been mixed in. The material for the next 48 hours gradually lost its cohesive character, and the slime was progressively dispersed. The pulp was thoroughly pressed on 28 7 32, no difficulty being experienced, for the juice separated with ease and the press residue was remarkably dry. The 24 gallons of juice were very cloudy and opaque, and again the pectinol treatment was adopted. 250 grs. D.R.-A pectinol were added, and after 24 hours signs of deposit on the bottom of the cask, together with several large clots of coagulated material on the top, were observed. The juice was now filtered with ease, producing a deep red, brilliant liquid which was used to prepare wines, syrups and concentrates.

The press residue (114 lbs. from 350 lbs. of fruit) was boiled for a few minutes with 14 gallons of water, and pressed. $16\frac{1}{4}$ gallons of a thick opaque juice (specific gravity 1.015, acidity, as malic acid, 1.11 per cent.) were recovered ; but filtration was found to be quite impossible. 72 lbs. of sugar were boiled with the juice, continuing until the scum was completely removed. The juice remained very cloudy and was again unfilterable. This material was re-boiled, and stored in 5-gallon porcelain jars.

The effect of heating the fruit before pressing was tried with 42 lbs. of ripe fruit in good condition. The fruits were milled, 1 gallon of water added, and the temperature raised to 140°F. and maintained there for 5 minutes. The pulp was pressed with ease whilst still hot. An enhanced colour of the product was very noticeable, as the heat treatment had extracted considerable quantities of colouring matter from the skins. Filtration was undoubtedly easier than with the first quantity of currants, whilst the final products were brilliant and noteworthy for their attractive appearance.

7. *Loganberry.* The extraction of a good yield of juice from loganberries presented no difficulties. 1 cwt. of fruit was pulped on 3 8 32, and pressed after 24 hours. 8 gallons of juice (71 per cent. yield) were obtained. To 4 gallons of this juice were added 50 grs. of pectinol, and after 24 hours the treated and control juices were filtered. Very little difference was noticed in the ease of filtration of the two juices, and both gave brilliant red products which were used for syrups. The press residue was soaked for 48 hours with $3\frac{1}{2}$ gallons of water. Pressure yielded 5 gallons of deep red juice (specific gravity 1.006), which was fortified by added sugar and fermented.

A further $9\frac{3}{4}$ gallons of juice was obtained from 1 cwt. loganberries after maceration with 2 gallons of water. Two wines, one sweet and the other dry, were prepared. The press residue was further extracted with 2 gallons of hot water and pressure yielded $2\frac{1}{4}$ gallons of a juice with a specific gravity of 1.006. This juice was used for wine.

8. *Blackberry.* $1\frac{1}{2}$ cwt. of poor quality berries were macerated in a barrel with 6 lbs. sugar. Fermentation commenced after 24 hours and 2 days later the juice was obtained with ease—14 gallons of juice representing a yield of 77 per cent. The juice was filtered through the wine filter, the colour being a brilliant dark crimson, and was quite the most attractive of the series. Various syrups, concentrates and a wine were made from the clear juice.

9. *Plum.* The following quantities of fruit were mixed together :—

167 lbs.	Yellow Egg	moderate condition.
33 lbs.	Victoria	poor ,,
30 lbs.	Blaisdon Red ..	sound ,,

All decomposed fruits were removed, but the Yellow Egg and Victoria plums were mostly in an over-ripe condition.

Various portions of the mixed fruit were boiled with water till soft, and the juice pressed out and filtered. After three filtrations the juice was fairly clear, but a persistent white haze permeated the juice and could not be removed.

Table I gives the analyses of some of the juices obtained during the 1932 season.

TABLE I.

Analyses of Fresh Juices Obtained from Various Fruits during 1932 Season.

Fruit	Variety	Specific Gravity	Acidity as Malic Acid %	Tannin %
Green Gooseberry ..	Keepsake	1.034	1.96	0.32
Red Gooseberry ..	Ironmonger ..	1.036	0.80	0.10
Strawberry	Royal Sovereign ..	1.054	0.95	0.19
Black Currant ..	Baldwin	1.034	1.21	0.14
Red Currant.. ..	Mixed	1.032	2.01	0.11
Raspberry	Baumforth A ..	1.041	2.23	0.13
,, ...	,, ..	1.032	1.88	0.17
,, ...	,, ..	1.030	1.57	0.10
Blackberry	Mixed Seedling ..	1.033	1.42	0.21
Loganberry ..	—	1.035	2.70	0.26
Plum	Mixed	1.031	0.90	0.18

Preparation of Fruit Syrups.

A number of syrups were prepared from the fresh fruit juices described earlier in this paper. Filtered juice was used and the added sugar dissolved either by boiling in a steam jacketed copper kettle until the scum could be permanently removed (hot process), or by continual stirring in the cold (cold process). The syrups made in this way contained about 60—63 per cent. of sugar corresponding to a specific gravity of 1.30—1.32. Syrups of this concentration of sugar remained free from fermentation, and kept indefinitely. Their use for dilution into beverages is vitiated by one serious drawback. The amount of sugar present is so large that very considerable dilution with water is necessary before the

required degree of sweetness is obtained. This dilution reacts unfavourably on the fruity flavour in the juice, which is so reduced that the resulting product lacks sufficient characteristic flavour necessary for a fruit drink. This can be overcome by preparing a syrup with 45 per cent. sugar, which needs considerably less dilution. The beverages then contain a correspondingly greater proportion of fruit flavouring. Such a syrup, however, is open to the constant risk of fermentation unless pasteurised and, if so processed, care is necessary to prevent the drink acquiring a " cooked " flavour. But it was found that 45 per cent. sugar syrups made from fruit juices were filterable through a Seitz E.K. film and sterility of the juice was thus ensured. Consequently, a series of 45° Balling syrups were made from several of the fruit juices. Some were pasteurised and others were filtered through a small laboratory Seitz filter with a capacity of half a gallon.

As the procedure was slightly varied in several cases, brief notes will be given for each syrup prepared.

Strawberry Syrup.

(*a*) *Hot process.* 5 gallons of strawberry juice were boiled with 105 lbs. sugar. After removal of scum, a somewhat hazy syrup was obtained which was poured hot into an earthenware jar and a quantity of glass bottles. Nine months after preparation, the syrup was still opaque, but there were no signs of fermentation, nor had any appreciable deposit collected. The syrup had a gravity of 1.355.

(*b*) *Cold process.* 4 gallons of filtered juice were mixed with 72 lbs. of sugar. $7\frac{1}{2}$ gallons of cloudy syrup were prepared in this way (specific gravity 1.326). After the 9 months storage period a light flocculent deposit had formed, but the syrup was still hazy. This was removable by filtration through flannel, but paper failed to remove the haze. Although slow, filtration through a Seitz K-film (clarifying film) was capable of giving a clear product.

The flavours of the two syrups were characteristic of the fresh fruit aroma.

The hot process syrup suffered from being too sweet, but the cold process product possessed a delicate aroma and flavour that was very attractive.

Red Currant Syrups.

(*a*) *Hot process.* $4\frac{3}{4}$ gallons of juice were inadvertently mixed with 78 lbs. sugar. The resulting syrup was too concentrated

(specific gravity 1.360). The colour was pleasant but the hazy character detracted severely from the appearance. After 9 months' storage there was little appreciable alteration.

(*b*) *Cold process.* In view of the persistent opacity of other similar products, the sugar was made into a syrup and boiled for some time and the scum (which was unexpectedly voluminous) removed. A clear syrup was obtained (1 cwt. in 4 gallons water), which on cooling was mixed with 4 gallons of clear red currant juice and stored as for other syrups. The colour was much lighter than with the hot process and after 9 months' storage, a brilliant product of specific gravity 1.294, with no deposit, was obtained.

The red currant syrups were disappointing. No characteristic flavour was noticeable, and it would have been very difficult to assign any definite fruit flavouring to the syrups.

Raspberry Syrups.

(*a*) *Hot process.* Raspberry juice treated with pectinol was used. 4 gallons were mixed with 75 lbs. sugar and boiled. A deep red syrup (gravity 1.342) was obtained. On cooling a slight haze was again apparent. After 9 months' interval the appearance was unchanged.

(*b*) *Cold process.* 4 gallons of juice were mixed with 60 lbs. sugar and the syrup filtered through paper (specific gravity 1.310). Very little difference in appearance was obvious between the two types of syrup.

There was considerable difference between the two flavours, the former being reminiscent of raspberry jam, whereas the cold process syrup was notable for its fresh fruit aroma and flavour.

Black Currant Syrups.

(*a*) *Hot process.* 75 lbs. sugar were dissolved by boiling in 5 gallons of juice (specific gravity 1.330). The clear syrup was filtered through muslin and the brilliant product stored in jars and bottles. This syrup provided the most attractive of the series. After an interval of 9 months the brilliancy was unimpaired, and no signs of deposit or fermentation were visible. The colour resembled the deep purple of the fresh fruit.

(*b*) *Cold process.* Similar amounts of juice and sugar were mixed, but the syrup (gravity 1.320) was markedly inferior to the hot process material.

The two syrups were characterised by a very pleasant and penetrating acidity which was similar to the fresh black currant flavour.

Loganberry Syrups.

Two gallons of juice and 31 lbs. of sugar were used in each process.

The hot process liquid possessed the deepest colour of the series, but there was a slight trace of whitish haze throughout the syrup. The cold process product was much more opaque, resulting in a diminution of colour. After 9 months' storage the former syrup was brilliant, but no change had occurred in the cold process syrup. It was observed that the top 2ins. of this latter syrup were brilliantly clear, whilst a slight flocculent deposit had settled to the bottom of the bottle. The specific gravity of both juices was 1.320.

The full fruit flavour and delicious aroma of both these syrups places them definitely as the best of the series.

Blackberry Syrup.

One concentrated syrup only was made from blackberries. $2\frac{1}{2}$ gallons of juice were boiled with 16 lbs. sugar, giving a syrup with specific gravity 1.260. A feature of the syrup was its rich purple colour, similar to the black currant products, but the flavour was spoilt by a bitter taste which greatly detracted from the general character.

45° *Balling Syrups.*

In the preparation of syrups containing 45 per cent. sugar either pasteurisation or Seitz filtering was necessary to prevent fermentation.

Data concerning these syrups after 6 months' storage are presented in Table II.

The results of observations on the 45 per cent. sugar syrups show that the colour and, to some extent, the flavour of the fresh fruit can be preserved by such treatment. The differences between samples sterilised by heat and by Seitz filtering are of interest, especially in view of the fact that by using the latter method syrups may be produced without the application of heat at any stage of the process. The deposits in all the cases, except the blackberry, were light in colour, and practically negligible in amount. The appearance of the products was generally remarkably good, especially in the case of Seitz filtered material. If pasteurisation is to be practised on a commercial scale the hazy effect

TABLE II.

FRUIT SYRUPS CONTAINING 45 PER CENT. SUGAR.

Fruit	Colour of Syrup	Clarity of Syrup	Deposit	Method of Sterilisation.	Remarks.
Strawberry	Bright red	Brilliant	None	Seitz filtration	Retained fresh fruit colour and flavour.
Red Currant	Pale red	,,	Very slight	,,	Rather pale, but flavour good.
,, ...	,,	Quite clear	,,	Pasteurisation	Not so pale, but flavour good.
Raspberry	Bright red	Brilliant	,,	,,	Attractive syrup with pleasant flavour, but slight suggestion of caramel.
,, ...	,,	,,	None	Seitz filtration	Attractive syrup with fresh fruit flavour.
Loganberry	Very rich crimson	,,	None	,,	One of the best syrups in every way.
,, ...	Deep red	Slight haze	Very slight	Pasteurisation	Inferior to previous sample.
Black Currant	Bright red	Clear	,,	,,	Attractive syrup. Good flavour.
,, ...	,,	Brilliant	None	Seitz filtration	Good appearance. Flavour good.
Blackberry	Deep red	Hazy	Moderate	Pasteurisation	Rather flavourless.

TABLE III.

Fruit Juices and Syrups Made by Various Processes.

Fruit	Preparation of Juice	Syrup	Clarity	Deposit	Method of Sterilisation
Red Currant ..	Fresh juice treated with pectinol and filtered	65°B.	Cloudy	Moderate	—
,, ..	Fresh juice unsweetened, treated with pectinol and filtered	—	Hazy	Very slight	Pasteurisation
Raspberry ..	Fresh juice unsweetened	—	Bright red colour, clear	,,	,,
,, ..	,,	—	,,	None	Seitz filtration
Loganberry ..	Second extraction of press residue. Gravity raised to 1.060	14°B.	Brilliant dark colour	None	Pasteurisation
,, ..	,,	,,	,,	None	Seitz filtration
,, ..	Fresh juice filtered clear, unsweetened	—	Hazy	Moderate	Pasteurisation
,, ..	,,	—	Clear	None	Seitz filtration
Black Currant ..	Fresh fruit boiled and juice filtered and sweetened	65°B.	Brilliant red	None	—
,, ..	,,	56°B.	,,	None	Pasteurisation
,, ..	,,	45°B.	,,	None	,,
,, ..	,,	40°B.	Brilliant deep red	None	,,
,, ..	Residue from pressing of boiled fruit soaked with hot water, and juice filtered and sweetened to specific gravity 1.090	21°B.	,,	None	,,
,, ..	Fresh juice filtered and unsweetened	—	Clear	Very slight	Seitz filtration
,, ..	,,	—	,,	,,	Pasteurisation
Blackberry ..	Fresh juice unsweetened	—	Clear	,,	,,
,, ..	,,	—	Deep red colour	None	Seitz filtration

associated with that treatment will probably not occur if a preliminary heating of the juice to a higher temperature than that used for the final pasteurisation is carried out.

Other Juices and Syrups.

Brief mention will be made of various products made from several kinds of fruits by different methods. Included in Table III are fresh juices treated in various ways for preservation, the results of which indicate the possibility of keeping such juices for several months.

The results obtained by using the juice from the second extraction of loganberry juice as the basis for a 14° Balling syrup were indicative of the possibility of making further use of the press-cake. The syrup was very attractive in appearance, and possessed a full fruity flavour characteristic of the loganberry. Fresh loganberry juice was shown to keep quite well when pasteurised or sterilised by filtration, but the flavour of the product had deteriorated considerably. Similar remarks may be made on the other fresh juices, all of which suffered considerably in this manner during storage.

The black currant juices prepared from boiled fruit were excellent in appearance and other properties. The flavour resembled that of cooked fruit, but this does not constitute so serious a disadvantage as in the case of a fruit which is normally eaten in the fresh uncooked state. A black currant syrup made from the residue from which the hot juice was pressed for the above juices, was similar to those syrups except in intensity of flavour.

Preparation of Fruit Juice Concentrates.

A series of concentrates were prepared from fresh juices by the vacuum distillation method. Two water pumps were used, and evaporation was carried out at 40°C. The fruits used were strawberries, black currants, red currants, blackberries, raspberries and loganberries.

Concentration was carried to various degrees to determine the effect of lesser or greater evaporation. The details for the concentrates are as follows :—

Strawberry. Specific gravity 1.275, dark red colour, very little deposit. The diluted sweetened concentrate was pleasant, but dissimilar in character to the fresh fruit beverage.

Red Currant. Specific gravity 1.30, very dark colour, heavy deposit. "Cooked" flavour very noticeable, but this concentrate has distinct possibilities of being converted into an attractive drink.

Loganberry. Specific gravity 1.275, very rich crimson colour, and slight deposit. The flavour retained little of its freshness, this marked departure from the other concentrates being probably due to the high acidity of the fresh juice.

Blackberry. Specific gravity 1.21, very deep colour, heavy deposit. This concentrate had undergone a slight fermentation in bottle.

Experiments on the utilisation of these concentrates have been commenced, but sufficient time has not yet elapsed for any report to be made on the matter.

Preparation of Wines.

1. *Green Gooseberry Wine.*

Thirteen gallons of juice, obtained from 1 cwt. of berries and 4 gallons of water were used for the preparation of three types of wine.

(*a*) *Sweet Gooseberry Wine* (fermented with Portuguese wine yeast). 5 gallons of juice were diluted on 27 6/32 with 3 gallons water and 28 lbs. sugar were stirred in. A small quantity of Portuguese wine yeast was added, and the juice allowed to ferment in a 9 gallon cask placed in a cool cellar. The initial gravity was 1.108. Fermentation proceeded rapidly for 5 days, then was retarded, and ceased completely at a specific gravity of 1.012. The gravity was raised to 1.020 by sugar,and the wine filtered clear with the wine filter. $4\frac{1}{2}$ gallons were set aside in cask for ageing experiments, whilst a number of champagne bottles were filled for comparison purposes and for analytical work.

The wine possessed the following analysis :—

Specific gravity 1.020, acidity (as malic acid) 0.74%, tannin 0.03%, alcohol (weight) 11.01%.

(*b*) *Dry Gooseberry Wine.* 5 gallons of juice were diluted with a syrup consisting of 12 lbs. sugar and 3 gallons water, and wine yeast added on 27 6 32. The original gravity of 1.066 had fallen to 1.015 after 4 days fermentation, but the gravity continued to fall slowly until the minimum figure of 0.996 was reached on 30 8 32. Sufficient sugar was added to raise the gravity to 1.000, and the wine was then treated exactly as the sweet type for storage.

The analysis was :—

Specific gravity 1.000, acidity 0.50%, tannin 0.03%, alcohol (weight) 7.36%.

The dry gooseberry wine was slightly lacking in body, but apart from this, it was quite an attractive product in its class and pleasant to taste.

(*c*) *Sweet Gooseberry Wine* (naturally fermented). The remaining 3 gallons of juice were fortified with 4 lbs. sugar and allowed to ferment in a glass vessel without addition of special yeast. The initial gravity was 1.100, and fermentation ceased at 1.010 on 29/8/32. The analysis of the sweetened wine was :—

Specific gravity 1.020, acidity 0.63%, tannin 0.03%, alcohol 9.80%.

This wine was characterised by its fullness of flavour as compared with the two previous wines. A pleasant acidity penetrated through the sweetness, and formed a brisk wine from what would otherwise have been somewhat heavy and uninteresting.

2. *Rhubarb Wines.*

The details of the five types of wine are tabulated on next page for convenience of comparison.

No. 1 was the best of the series possessing a pleasant aroma, well balanced clean flavour, and absence of any deposit which contributed to the production of a very good wine.

No. 2 suffered from lack of "body," but the flavour was clean to the palate.

No. 3 was notable on account of a rather bitter flavour which was obvious to the palate. The presence of this flavour in No. 3 is surprising, as it would naturally be assumed that the most flavour would result from the milled sample.

No. 4 was not a good wine, lacking character and flavour.

No. 5 was the only wine of the series to be at all coloured, possessing an attractive pink colour, considerable rhubarb flavour, and an enhanced acidity. This wine must be considered as the second best of the series. It was more reminiscent of real rhubarb flavour than No. 1.

In rhubarb, as in other wines to be mentioned later, the dry type of wine was not satisfactory.

3. *Sweet Strawberry Wines.*

(*a*) A sweet wine was prepared from 4 gallons of the main bulk of fresh strawberry juice mixed with 3 gallons of juice obtained from the second pressing. 20 lbs. sugar and 1 gallon of water were added and later a small quantity of wine yeast. Fermentation

TABLE IV.

DATA RELATING TO RHUBARB WINES.

Treatment of Rhubarb	Type of Wine	Fermentation Commenced	Fermentation Ceased	Specific Gravity at end of Fermentation	Analysis of Wine.			
					Specific Gravity	Acidity	Tannin	Alcohol (by weight)
1. Milled	Sweet	27/6/32	15/9/32	.9990	1.020	0.40%	0.04%	10.63%
2. ,, ...	Dry	,,	1/9/32	.9960	1.000	0.34%	0.03%	6.41%
3. Whole sticks soaked in water + sugar ..	Sweet	,,	15/10/32	1.010	1.020	0.34%	0.02%	8.33%
4. ,, ..	Dry	,,	29/9/32	.9980	1.000	0.34%	0.02%	4.75%
5. Whole sticks pressed	Sweet	,,	16/8/32	1.017	1.020	0.70%	0.02%	9.20%

was protracted (probably on account of the sulphur dioxide introduced in the initial preparation of the juice). The original gravity on 8 7 32 was 1.110 and this had fallen to 1.056 (13 8 32) and 1.052 (29 8 32), from which point the loss in gravity was extremely slow. The cask was removed to a warm room, and small amounts of wine yeast added at intervals in a media containing malt extract and ammonium phosphate. The gravity reached 1.022 on 19 2 33, at which stage the wine was filtered, yielding an attractive golden yellow product.

The analysis was as follows :—

Specific gravity 1.022, acidity 0.59%, tannin 0.09%, alcohol (by weight) 11.33%.

This wine was outstanding for its excellent bouquet, very characteristic flavour, and well balanced qualities. It was perhaps a little too heavy, but a mixture of this with the succeeding wine removed this defect and gave an excellent product.

(*b*) A second sweet wine was made from juice furnished by the second pressing. 9 gallons of juice (specific gravity 1.040) were fortified with sugar to a gravity of 1.075 and fermented with wine yeast. It is interesting to note that the fermentation continued steadily until the gravity fell to 1.023 on 10/1 33, at which date the gravity of the wine made from the first pressed juice stood at 1.049. The wine was quite clear, and on filtration gave a bright yellow wine, not so attractive as the former sample but possessing definitely attractive features.

The analysis was :—

Specific gravity 1.023, acidity 0.47%, tannin 0.07%, alcohol 8.19%.

This wine was similar to the preceding sample except in the degree of flavouring. The essential characters were not so prominent, and for this reason the wine, although prepared from second pressings of juice, compared very favourably with the wine made from the initial pressing. Both wines were crystal clear and free from deposit.

4. *Red Currant Wines.*

Two wines were prepared from juice obtained from 120 lbs. red currants on 27/7/32. The proportions used were :—

Sweet Wine. 2 gallons juice, 1½ gallons water, 10 lbs. sugar.
Dry Wine. 2 gallons juice, 2 gallons water, 5 lbs. sugar.

The wines fermented with wine yeast in 4½ gallon casks. The gravity of the sweet wine had fallen to 1.020 by 29 8/32, beyond which point no further fermentation occurred. The second wine had become quite dry by 29/8/32 and was quite brilliant.

The juice from the second extraction of the red current press-cake was fortified to 1.085 with sugar and fermented. However, it was only with difficulty that the gravity fell below 1.055, and a temperature of 60°F. and addition of several quantities of fresh wine yeast were necessary before the desired gravity was reached on 2/2/33.

The analyses are tabulated below :—

Red Currant Wine	(sweet)	Specific gravity 1.020, acidity 1.24%, tannin 0.04%, alcohol 8.84% (weight).
do.	(dry)	Specific gravity 1.000, acidity 1.09%, tannin 0.03%, alcohol 5.13% (weight).
do.	(second pressed juice)	Specific gravity 1.023, acidity 0.71%, tannin 0.04%, alcohol 7.56% (weight).

All the wines were too acid to be regarded favourably. The sweet wine possessed a fine deep red colour, and characteristic red currant flavour, but the acidity spoilt the balance of flavours. The dry wine naturally suffered more from the high acidity, being almost undrinkable.

The second pressing of juice made a very fair, almost colourless light wine, whilst a blend of the dry and " seconds " wines produced a very good medium dry wine.

5. *Raspberry Wines.*

1½cwts. of Baumforth A fruit (jam quality) were used for wines. The treatment of the fruit has already been given. The juice was modified on 27/7/32 as under for fermentation :—

Sweet Wine. 5 gallons juice, 3 gallons water, 20 lbs. sugar.
Dry Wine. 5 gallons juice, 3½ gallons water, 8 lbs. sugar.

Both juices fermented rapidly in the early stage. The sweet wine fell to a gravity of 1.022 on 29/8/32 and 1.010 on 21/12/32, when fermentation ceased. The dry wine had fallen to 1.004 by 30/8/32. Both products were brilliantly clear and filtration was hardly necessary.

The analyses of the final products were :—

Raspberry Wine	(sweet)	Specific gravity 1.020, acidity 1.35%, tannin 0.04%, alcohol 10.21%.
do.	(dry)	Specific gravity 1.004, acidity 1.38%, tannin 0.04%, alcohol 7.68%.

The flavour of the wines was characteristic of the raspberry, but the presence of rather considerable quantities of acetic acid, caused by the access of air to the wine, spoilt the delicate fruit flavour. A series of wines were made by sweetening the two wines describe above with varying quantities of sugar. The sweet wine, furthe

sweetened to a specific gravity of 1.045, was a pleasant heavy dessert wine, in which the acetic flavour lost its former prominence.

6. *Loganberry Wines.*

The juice from 1 cwt. of fruit was used to make a sweet and a dry wine.

Sweet Wine. 4 gallons juice, 2¾ gallons water, 32 lbs. sugar.
Dry Wine. 4 gallons juice, 4 gallons water, 12 lbs. sugar.

Both wines fermented very slowly. This was no doubt due to the dilution of yeast food in the juice caused by the dilution with water which was necessitated by such a high acidity as that of the fresh loganberry juice. The dry wine was filtered on 20 2 33, by which date natural clarification had produced a clear wine. The sweet wine was placed in a warm room shortly before Christmas 1932, and several additions of yeast and malt extract media were made. The wine was filtered on April 21st, 1933, at a specific gravity of 1.032.

Two further wines were made to examine the possibility of utilising press residues to impart a different type of flavour to the product. The residue from 1 cwt. of fruit was soaked for 48 hours with 3½ gallons water. After pressing, 5 gallons of dark red juice were collected (specific gravity 1.006). This was strengthened with 12 lbs. sugar to a gravity of 1.100, and fermented with wine yeasts. A rapid initial fermentation ensued, but the gravity did not fall to 1.020 until 6 3 33, despite the fact that elevation of temperature and addition of new yeast and yeast food were resorted to at intervals. The wine was easily filtered to a deep red product ("Seconds" No. 1).

The residue from a further cwt. of berries was extracted with 2 gallons of hot water. 2¼ gallons of juice were obtained which were mixed with one quart of fresh juice and 16 lbs. sugar and fermented with wine yeast. Fermentation was very slow, and the last 20 points fall in gravity was only obtained after transferring the cask to a warm room (60°F.) and adding a vigorous cider yeast of the Broadleaf Norman type. The wine was filtered on April 21st, 1933 ("Seconds" No. 2). The analyses of the juices are shewn below:—

Loganberry Wine (sweet)		Specific gravity 1.032, acidity 1.18%, tannin 0.10%, alcohol 11.88%.
do.	(dry)	Specific gravity 1.000, acidity 1.20%, tannin 0.06%, alcohol 8.33%.
do.	"Seconds" No. 1	Specific gravity 1.020, acidity 0.76%, tannin 0.13%, alcohol 11.0%.
do.	"Seconds" No. 2	Specific gravity 1.035, acidity 1.000%, tannin 0.09%, alcohol 10.06%.

The sweet loganberry wine possessed many attractive features, but it is probable that the character of the wine will be altered on storage. The flavour and aroma were remarkably rich and, when

the various constituents have blended more satisfactorily, a very good wine should result. The dry wine was interesting on account of the " masking " of the high acidity by compounds other than sugar present in the wine. It constituted the best dry wine of the series. The colour was brilliant red, and the aroma definitely resembled the fresh loganberry flavour.

The " Seconds " No. 1 wine was excellent in colour and flavour. The latter was well balanced, with a pleasing acidity dominating the other characters. This wine is of interest as an example of the type of product which can be obtained from the press residue of loganberries.

In the " Seconds " wine No. 2 a foreign flavour, not unpleasant, was noticeable. It may be presumed to be due to the preliminary treatment with hot water extracting some less soluble compounds characterised by their somewhat pungent and bitter taste. However, this fact did not counterbalance the good features of the wine, which, again, should improve with storage.

7. *Black Currant Wines.*

Black currant juice, obtained as described previously was used, in part, for the preparation of two wines.

Sweet Wine. 2¾ gallons juice, 3 gallons water, 16 lbs. sugar.
Dry Wine. 1½ gallons juice, 3 gallons water, 6 lbs. sugar.

Both wines fermented slowly and before Christmas were transferred to a room at 60°F. and small quantities of wine yeast and ammonium phosphate added. The filtered wines did not reveal the characteristic colour intensity of the fruits, but an attractive red wine was produced. Only details of the dry wine are given, as the sweet wine was not fermented sufficiently to filter at the time of writing.

Black Currant Wine (dry) Specific gravity 1.003, acidity 1.22%, tannin 0.10%, alcohol 8.05%.

The dry wine was similar to other dry products obtained in this series. It was thin, and the flavour, whilst not being definitely unpleasant, lacked the qualities of balance and mellowness which are necessary. It is very probable that storage for a year will improve the product.

8. *Blackberry Wine.*

2½ gallons of filtered blackberry juice were added to 1¼ gallons of thick material (unfiltered), 10 lbs. sugar dissolved in the mixture, and fermentation induced by means of wine yeast. In this sample also, difficulty was found in fermenting the liquor, and similar aids were adopted to those for the black currant wine.

The juice was filtered at a gravity of 1.027 on April 21st, 1933, its analysis being :—

Specific gravity 1.027, acidity 0.98%, tannin 0.11%, alcohol 9.06%.

Observations on the Prepared Wines.

From the observations reported on the various wines the fact emerges that as a class the sweet wines are greatly superior to the dry products. It is quite possible that the rough unbalanced flavours associated with the latter are merely transitory and that the mellowing and softening associated with ageing processes will considerably improve their all-round character. This will probably also apply to those in the sweet series. It is necessary to emphasise again at this point that the remarks made on the various wines represent attempts to assess their different characteristics at a period of immaturity and may not apply to the matured products.

The very high acidities encountered in the juices used as the basis for the wines introduces a complication when degrees of sweetness or dryness are being considered. A dry wine containing 1 per cent. of acidity (calculated as malic acid) is almost undrinkable, even with an alcoholic content of 5—6 per cent. In the case of the red currant dry wine, an acidity of 1.09 per cent. was associated with an alcohol content of 5.13 per cent. This wine was produced by diluting fresh red currant juice with an equal volume of water, and subsequently adding sugar. The dilution of a juice to such an extreme degree naturally leads to a slower fermentation on account of the smaller amount of nitrogenous material present, which acts as an important and essential yeast food. This reduction in the rate of fermentation is clearly seen in the results obtained and reported above. Very protracted fermentations occurred in several wines, notably the black currant wines and in products prepared from the second extractions of juice from the pressed fruit material. Should the initial fermentation be slow, there is a decided danger of the incidence of acetification, but a retardation of the fermenting process in the later stages is not of such a serious nature on account of the inhibiting action of amounts of alcohol greater than 6—8 per cent. on the various bacilli contributing to formation of acetic acid.

The dilution of the juice naturally affects the strength of characteristic fruit flavour in the finished product, but experience gained in the pursuance of these experiments tends to show that no deleterious effects are to be expected from this cause. A too pronounced flavour of the fruit used is not to be recommended as the delicacy of bouquet and aroma are not thus enhanced.

An interesting feature of the series of wines is the quality of those products in which juices obtained by a second extraction of the pressed material were utilised. In each of the cases the maximum possible yields of juice were obtained by the initial

hydraulic pressing and the pressed material was then soaked in water for varying periods. It was noticeable that these wines retained considerably greater amounts of flavouring and aroma than was expected. The practice of allowing fermentation to commence whilst the macerated press cake is in contact with the added water (together with some sugar) is probably the cause of this ; the action of the yeasts will certainly lead to a disruption of nearly all the entire cells with the consequent addition to the liquor of the aromatic contents of the cell. The wines were not satisfactory without the addition of sugar before bottling. A trace of " bitterness " was associated with most of the products and to prevent the spoliation of flavour, etc., by reason of this, sweet wines were prepared and proved to be more acceptable than the corresponding completely dry products.

Table V contains data for wines made during the 1932 season at Long Ashton, and Table VI presents analyses of some similar wines prepared in Continental countries.

TABLE V.

ANALYSES OF FRUIT WINES PREPARED AT LONG ASHTON IN SEASON 1932—1933

Fruit	Preparation of Juice	Type of Wine	Specific Gravity	Alcohol (weight) per cent.	Alcohol (volume) per cent.	Acidity (as malic acid)
Gooseberry ..	—	Sweet	1.020	11.01	13.63	0.74
,, ..	—	Dry	1.000	7.36	9.15	0.50
,, ..	—	Sweet	1.020	9.80	12.14	0.63
Rhubarb ..	Milled sticks	Sweet	1.020	10.63	13.16	0.40
,, ..	do.	Dry	1.000	6.41	7.99	0.34
,, ..	Whole sticks	Sweet	1.020	8.33	10.35	0.34
,, ..	do.	Dry	1.000	4.75	5.93	0.34
,, ..	Whole sticks pressed	Sweet	1.020	9.20	11.41	0.70
Strawberry ..	—	Sweet	1.022	11.33	14.01	0.69
,, ..	Second extraction of juice	Sweet	1.023	8.19	10.17	0.47
Black Currant ..	—	Dry	1.003	8.05	10.00	1.22
Red Currant ..	—	Sweet	1.020	8.84	10.96	1.24
,, ..	—	Dry	1.000	5.13	6.40	1.09
,, ..	Second extraction of juice	Sweet	1.023	7.56	9.40	0.71
Raspberry ..	—	Sweet	1.020	10.21	12.64	1.35
,, ..	—	Dry	1.004	7.68	9.55	1.38
,, ..	Second extraction of juice	Sweet	1.022	9.50	11.77	0.66
Blackberry ..	—	Sweet	1.027	9.06	11.23	0.98
Loganberry ..	—	Sweet	1.032	11.88	14.68	1.18
,, ..	—	Dry	1.000	8.33	10.35	1.20
,, ..	Second extraction of juice	Sweet	1.020	11.00	13.62	0.76
,, ..	do.	Sweet	1.035	10.06	12.46	1.00

TABLE VI.

ANALYSES OF TYPICAL WINES PREPARED IN GERMANY AND FRANCE FROM SOFT FRUITS.*

Wine.	Type	Specific Gravity	Alcohol (weight) per cent.	Alcohol (volume) per cent.	Acidity (as malic acid)	Sugar %
Gooseberry ..	Dry	0.9932	8.19	10.17	0.81	0.08
,, ..	Sweet	1.023	10.94	13.53	0.77	9.79
Strawberry ..	Sweet	1.060	10.33	12.80	1.07	18.01
,, ..	,,	1.035	8.40	10.42	0.62	—
,, ..	,,	1.048	9.75	12.10	0.81	14.11
Black Currant	—	—	11.88	14.68	1.59	8.90
,, ..	Dry	0.9999	12.65	15.60	1.33	2.52
,, ..	Heavy cassis	1.017	10.81	13.37	0.71	6.11
,, ..	Dessert wine	1.006	10.73	13.28	0.74	3.52
Red Currant	French(sweet)	1.061	11.66	14.42	1.12	—
Raspberry ..	Sweet	1.046	10.10	12.50	0.71	12.44
Blackberry ..	Sweet	—	10.93	13.51	0.96	16.55
,, ..	,,	1.026	7.98	9.91	0.79	—

* Table VI extracted from "Chemie der menschlichen Nahrungs-und-genussmittel" (König) I, p. 1396.

SUMMARY.

1. The problem of the utilisation of poor quality fruits under modern marketing conditions is discussed, and the possibility of the production of juices, syrups, concentrates and wines as an outlet for such material is indicated by reference to Continental and American developments in this by-products industry.

2. Details of the methods of preparation of similar classes of products are presented, together with data concerning quality and appearance.

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INVESTIGATIONS ON FRUIT PRODUCTS.

II.—ENZYMIC CLARIFICATION OF FRUIT JUICES.

By Vernon L. S. Charley.

The manufacture of fruit syrups, beverages and concentrates from the various fruits in common cultivation entails three distinct stages :—

(*a*) extraction of the juice,
(*b*) clarification of the expressed juice,
(*c*) treatment of the clear juice in detailed ways to prepare the particular products required.

Of these three, the clarification of the juice presents the greatest difficulties, for fruit juices in general are characterised by high viscosity. A freshly expressed juice contains colloidal protein, carbohydrate and pectous materials which exert an influence altogether disproportionate to the amounts present, for not only do these compounds themselves materially contribute to the slimy character of the juice, but they also act as " protective " agents for many other compounds which are held in loose physical combination.

Filtration of the fresh juice is not a practical proposition. A clear filtrate can be produced by passing fresh juice through an ordinary pulp filter similar to that in general use for cider, but the rate of filtration is slow at the commencement of the operation and soon ceases completely owing to the clogging of the pores of the filter packing by the deposit and slimy contents of the juice.

The production of a perfectly clear juice free from deposit is an important aim of the manufacturer. The psychological effect on the public of a brilliantly clear juice cannot be over-estimated ; indeed, the failure of the sales of " sweet cider " (unfermented apple juice) to compete with the consumption of synthetic fruit beverages in America is explained in part by Caldwell (1) as being due to the opalescent nature of the pure fruit beverages offered to the consumer. It would appear that brilliance is of paramount importance, and for this reason various methods have been tried to clarify the fresh juice before it is sweetened or otherwise treated.

Historical.

Clarification of various foodstuffs and beverages has been practised for many years. The efficient and economical clearing of beer has been, and indeed, still remains one of the major problems of the brewing industry. The wine trade, too, has its own specific problems bearing on this question, and methods introduced to solve the problems of these two classes of products have been adapted for use with fruit juices.

The various methods of clarification aim at producing a product which shall be easily filterable through an ordinary pulp filter, giving a brilliant juice. If the fresh juice be heated, the colloidal aggregates are decomposed or coagulated and filtration is considerably hastened, although there is the distinct possibility of introducing an unpleasant flavour by the heat treatment. Various adsorption methods are in vogue, such as adsorbing the colloids of the juice on the surface of special adsorbent materials such as Spanish clay, fuller's earth and various brands of charcoal. Many of these treatments result in a loss of colour and, in some, the adsorbing agent imparts a slight but definite taint to the juice.

Previous to 1912 clarification by enzymes had been considered as too difficult of application and uncertain in effect for commercial usage, but in that year the Wallerstein process was introduced (2) for preventing the appearance of a haze in bottled beer. It was supposed that the haze was due to the formation of a colloidal protein-tannin complex. The addition of a proteolytic enzyme prevents the deposition of the precipitate which frequently forms on cooling.

Caldwell (3) studied the application of enzymes to fruit juices. He states (page 4), " Because of the number and diverse character of the constituents which it is desirable to remove, as well as the character of those which must be preserved, it appears inherently impossible that enzymes could be successfully employed in the clarification of apple or grape juice or that, even if such a process could be developed. it could be made of such a character as to be generally usable."

Takamine (4) prepared from moulds and other micro-organisms solutions of enzymes which were used for the clarification of fruit juices. Many of these were concerned primarily with the conversion of starch to simpler compounds and in this connection Takadiastase and Polyzyme have received increasing recognition since their introduction in 1913. The action of these enzyme solutions is not confined to one definite type of reaction, because a number of enzymes, each specific in its individual action, are

present. For instance, it is stated that Polyzyme decomposes starch, fats and proteins to simpler compounds.

The influence of pectin on the clarity of apple juices has been especially studied by the French cider workers. The cider makers in that country have laid stress on the necessity of decomposing the pectin compounds in the fresh juice by pectase before allowing fermentation to ensue. Warcollier (5) cites the removal of pectin by pectase as one considerable advantage associated with the process of " vatting " or keeving the fresh juice. He states that ciders prepared in such a way clear better and yield superior products. Kertesz published details in 1930 (6) and Willaman and Kertesz (7) in 1931 of a new enzyme for decomposing some pectins and precipitating others. The " protective " action of the pectins is immediately destroyed and the compounds which have been held in suspension by association with the pectin are precipitated. The enzyme is prepared by growing the mould, *Penicillium glaucum*, on a medium consisting of a physiological salt solution together with sucrose and pectin. Solid or liquid preparations may be used. The optima for the enzymes were found to be pH = 3.0—3.5, temperature 104°F. (=55°C.) for 30 minutes. The action of the enzyme appears to be specific towards pectin, for no change in starch content was observed. The use of the enzyme is quite simple. The solid or liquid form is well mixed with the juice to be clarified and the mixture allowed to stand for a given period. The time taken is inversely proportional to the amount of enzyme used, so that one can regulate the duration of the treatment (a very necessary condition when non-alcoholic juices are being prepared) by the addition of more or less enzyme as each case demands. Kertesz states that after 10—15 hours, using sufficient enzyme, fresh apple juice can be filtered with ease ; a centrifuge is recommended, which, under correct conditions, will produce a perfectly clear juice ready for carbonation and bottling.

This enzyme is now produced on a commercial scale under the name of " Pectinol " and various reports on its action have appeared. Marshall (8) confined his attention to apple juice, using a liquid form of pectinol. Very satisfactory results are reported, which are discussed in more detail in a later paper of this series (Non-alcoholic Apple Juice, this Report p. 214). Carpenter and Walsh (9) also using apple juice and pectinol E obtained similar results, but stated that the periods necessary for completion of the reactions had been understated by the manufacturers.

No details of the application of enzyme reactions to fruit juices other than apple and grape, have been found in the literature.

Consequently during the summer of 1932, a series of experiments were carried out at Long Ashton by the author with the object of determining the necessary conditions for such treatment.

Experimental.

The trials were so designed as to enable small quantities of juices to be used. In all the series two litres of juice were utilised for each test. The pectinol was well mixed into the juice and observations made at stated intervals. The determination of pectin was according to the method of Carré and Haynes (10), involving the estimation of calcium pectate. At the conclusion of the experiment the various juices were first filtered through paper and later through a Laboratory Seitz E.K. filter, being finally bottled in sterile bottles.

The data obtained are tabulated under the various fruits concerned.

Strawberry Juice.

Analysis of juice : specific gravity 1.026, acidity (as malic acid) 0.63 per cent., tannin 0.17 per cent.

Temperature of juice during experiment, 60°F.

TABLE I.

Experiment No.	1	2	3	4
Pectinol % added (WT/VOL) ..	0.1	0.5	1.0	Nil—Control
Appearance of juice after 6 hours ..	Cloudy, slight deposit	Cloudy, slight deposit	Fairly clear, heavy deposit	Thick and opaque—no deposit
Appearance of juice after 12 hours ..	Clearer, more deposit	Clear, heavy deposit	Brilliant, heavy deposit	,,
Appearance of juice after 24 hours ..	Brilliant, heavy deposit	Brilliant, heavy deposit	,,	,,
Specific gravity after 48 hours ..	1.015	1.010	1.008	1.019
% Calcium pectate in juice after 24 hours	0.421	0.401	0.320	0.427
Appearance after 1 month in bottle	No deposit	No deposit	No deposit	No deposit
Appearance after 3 months in bottle	Clear, slight deposit	Clear, slight deposit	Clear, very slight deposit	,,

N.B.—1% Pectinol (WT/VOL) is equivalent to 160 ozs. per 100 gallons.

The results indicate that strawberry juice can be satisfactorily cleared from colloidal material by treatment with 0.1 per cent. pectinol for 24 hours, or 1.0 per cent. pectinol for 12 hours.

The appearance of slight deposits in the Seitz filtered bottled juices after 3 months suggests that the enzyme remained active subsequent to filtration.

The specific gravity figures show significant variations, but the results when considered with those of other juices are inconsistent.

Red Currant Juice.

Analysis of juice : specific gravity 1.032, acidity (as malic acid) 2.01 per cent., tannin 0.11 per cent.

Temperature of juice during experiment, 60°F.

TABLE II.

Experiment No.	1	2	3	4	5	6
Pectinol % added (WT/VOL)	0.05	0.25	0.5	1.0	2.5	Nil—Control
Appearance of juice after 12 hours	Same as No. 6	Same as No. 6	Same as No. 6	Same as No. 6	Same as No. 6	Cloudy, no deposit
Appearance of juice after 24 hours	Little clearer	No change	No change	No change	No change	No change
Appearance of juice after 36 hours	Clear	Hazy	Slight haze	Very little clearer	Very little clearer	Hazy
Specific gravity after 48 hours	1.026	1.030	1.030	1.031	1.030	1.020
% Calcium pectate in juice after 24 hours	0.329	0.327	0.330	0.312	0.251	0.328
Appearance after 1 month in bottle	Clear, no deposit	Clear, no deposit	Clear, no deposit	Clear, no deposit	Clear, no deposit	Clear, no deposit
Appearance after 3 months in bottle	,,	,,	,,	,,	Slight haze & deposit	,,

The series of tests with red currant juice did not give well defined results. The best clarification was obtained with the control and the minimum amount of enzyme. In the case of No. 6, the juice had undergone considerable fermentation and this caused the clearing which is usually associated with fermenting juices. No. 1, also owed its partial clearing to fermentation, but in the other cases the enzyme had little effect. The high acidity of the juice was probably the cause of this. No evidence was found of continuation of enzyme action after Seitz-filtering the juices, except the trace of deposit in No. 5.

Black Currant Juice.

Analysis of juice : specific gravity 1.034, acidity (as malic acid) 1.21 per cent., tannin 0.14 per cent.

Temperature of juice during experiment, 60°F.

TABLE III.

Experiment No.	1	2	3	4	5	6	7
Pectinol % added (WT/VOL)	Nil—Control	0.05	0.1	0.5	1.0	2.0	Nil—Control
Appearance of juice after 24 hours	Very thick	As No. 1	As No. 1	As No. 1	As No. 1	As No. 1	As No. 1
Appearance of juice after 48 hours	,,	,,	,,	,,	Clearer	Clear	,,
% Calcium pectate in juice after 48 hours	0.362	0.292	0.290	0.281	0.228	0.228	0.368
Appearance after 3 months in bottle	No deposit	As No. 1	As No. 1	As No. 1	As No. 1	As No. 1	As No. 1

The action of pectinol is shown clearly by the figures for calcium pectate. The reduction of soluble pectin is increased as the amount of enzyme increases, the maximum decomposition being in Nos. 5 and 6, where approximately 40 per cent. of the pectin is lost. The only experiment which yielded results which would be of any practical importance was No. 6, in which a fairly clear juice was obtained.

In the course of the preparation of a series of fruit juices a bulk of black currant juice was available, and an experiment was carried out with pectinol. 24 gallons of juice (containing 2 gallons added water) were treated with 750 grams pectinol and allowed to remain perfectly still at a temperature of 65°F. for 48 hours. The calcium pectate content of the juice before treatment was 0.186 per cent., and after 48 hours the figure was 0.083 per cent. Filtration was perfectly easy, and a brilliant product, with 0.062 per cent. calcium pectate, was obtained.

Loganberry Juice.

Analysis of juice : specific gravity 1.035, acidity (as malic acid) 2.70 per cent., tannin 0.26 per cent.

Temperature of juice during experiment, 70°F.

TABLE IV.

Experiment No.	1	2	3	4
Pectinol % added (WT/VOL) ..	0.1	0.5	1.0	Nil—Control
Appearance after 24 hours ..	Cloudy	Cloudy	Cloudy	Cloudy
Appearance after 48 hours ..	,,	,,	Fairly clear slight deposit	Rather clearer than No. 3
Appearance after 3 months in bottle	Clear, no deposit	As No. 1	As No. 1	As No. 1

Some clearing was effected after 48 hours by the addition of 1.0 per cent. pectinol. The fact that the control sample was slightly clearer than No. 3 (1.0 per cent. pectinol) may be attributed to fermentation. The temperature was higher than for the other series and fermentation commenced very soon after the expression of the juice. However, experience gained during the 1932 season with a larger bulk of loganberry juice suggests that a period of 48 hours during which the juice ferments in contact with the crushed pulp results in an expressed juice which is quite satisfactorily filtered without further treatment. It would appear that some preliminary fermentation of the loganberry pulp is the most efficacious means of reducing the colloidal pectous material.

Raspberry Juice.

Analysis of juice: specific gravity 1.030, acidity (as malic acid) 1.57 per cent., tannin 0.10 per cent.

Temperature of juice during experiment, 65°F.

TABLE V.

Experiment No.	1	2	3	4	5	6
Percentage of pectinol (WT/-VOL)	0.05	0.1	0.5	1.0	2.0	Nil—Control
Appearance of juice after 12 hours	Opaque, heavy deposit	Slightly clearer than No.1	Opaque, heavy deposit	Opaque, heavy deposit	Hazy, heavy deposit	Clearing well (fermenting)
Appearance of juice after 24 hours	Hazy	Same as No. 1	Same as No. 1	Same as No. 1	Same as No. 1	Clear (gel. formed on top)
Specific gravity of juice after 48 hours	1.011	1.011	1.012	1.014	1.015	1.006
Calcium pectate % in juice after 12 hours	0.436	0.439	0.427	0.420	0.422	0.435
Calcium pectate % in juice after 48 hours	0.367	0.351	0.372	0.271	0.233	0.391
Appearance of juice in bottle after 3 months	Clear, very slight deposit	Clear, no deposit	Clear, slight deposit	Clear, slight deposit	Clear, slight deposit	Clear, very little deposit

The interpretation of the figures and observations obtained for raspberry juice is complicated by the early occurrence of fermentation in some of the juices under examination. The fruit used for the tests was poor quality material which was already beginning to decompose. The addition of greater amounts of pectinol inhibited fermentation to a slight degree, without effecting any appreciable change in the appearance of the juice. In the 24 hours series, Experiment No. 6 exhibited a peculiar phenomenon. The juice had cleared very satisfactorily—and the sediment was occluded in a gel-like formation on the surface of the liquid. The

lower portion of the liquid was, however, perfectly brilliant. The figures for calcium pectate indicate how difficult it is to correlate successfully the pectin content of the juice with its appearance. In the 48 hour series, the appearances of juices Nos. 3, 4, and 5 were indistinguishable one from another, but the calcium pectate figures differed by over 40 per cent. Some evidence of a continuation of enzyme action subsequent to filtration through the Seitz E.K. film was observed. Slight deposits were found in all cases, and by microscopic examination these were shown to be amorphous in nature, with no observable yeast cells present.

A further experiment was carried out on 12 gallons of raspberry juice, of specific gravity 1.032, acidity (as malic acid) 1.88 per cent., and tannin 0.17 per cent.

A sample of the juice (A) was kept as a control and 250 grams. of pectinol were added to the remaining quantity of juice (B). The analytical data and observations are given in Table VI.

TABLE VI.

Date	Hours after addition of Pectinol	A. Control. No Pectinol.			B. 250 grams. Pectinol Added.		
		Specific gravity	Calcium pectate %	Appearance	Specific gravity	Calcium pectate %	Appearance
23/7/32 (noon)	—	1.032	0.339	Opaque, no deposit	1.032	0.339	Opaque, no deposit
25/7/32 ..	45	1.030	0.307	Little clearer, some deposit	1.023	0.228	Opaque, very slight deposit
26/7/32 ..	72	1.026	0.295	Little clearer, heavy deposit	1.012	0.115	Clearer, fair deposit
27/7/32 ..	96	1.018	0.270	No change, heavy deposit	1.012	0.115	Clearer, fair deposit
28/7/32 ..	120	1.016	—	,,	1.012	—	,,

On 28 7 32, the Control was definitely clearer than the treated juice. There could be little doubt that this was due to fermentation, the sudden clarification of the Control juice after 45 hours coinciding with a fall in gravity from 1.023 to 1.012. During the period in which little fermentation occurred, that is until 45 hours from the commencement of the trial, the pectinol had effected some favourable change in the clarity of the juice, but beyond that time very little further change was noted. The final juices, with gravities of 1.016 and 1.012, filtered remarkably well, and both furnished bright attractive products.

Plum Juice.

Analysis: specific gravity 1.031, acidity (as malic acid) 1.01 per cent., tannin 0.18 per cent.

Temperatures of experiment, 60°F. and 110°F.

Volume of juice used for each experiment=4,500 cc. (1 gallon).

TABLE VII.

Experiment No.	1		2		3		4	
Temperature	60°F.	110°F.	60°F.	110°F.	60°F.	110°F.	60°F.	110°F.
% pectinol in juice (WT/VOL)	0.1	0.1	0.5	0.5	2.0	2.0	Nil—Control	Nil—Control
Appearance of juice after 2 hours	Opaque, no deposit	Opaque, no deposit	Opaque, no deposit	Opaque, no deposit	Opaque, no deposit	Opaque, no deposit	Opaque, no deposit	Opaque, no deposit
Appearance of juice after 6 hours	,,	,,	,,	Opaque, fair deposit	Clearer, heavy deposit	Much clearer, heavy deposit	,,	Very slightly clearer
Appearance of juice after 12 hours ..	,,	,,	,,	Opaque, heavy deposit	Clear, heavy deposit	Clear, heavy deposit	,,	Very slightly clearer, some deposit
Appearance of juice after 24 hours ..	Clearer, slight deposit	Clear, heavy deposit	Clear, no deposit	Clear, heavy deposit	,,	,,	,,	Fermenting
Appearance of juice after 48 hours ..	Clear, fair deposit	,,	,,	,,	,,	,,	Clearer (due to fermentation)	Cloudy, heavy deposit
% Calcium pectate in juice after 2 hours ..	0.165	0.166	0.150	0.136	0.153	0.119	0.165	0.164
% Calcium pectate in juice after 6 hours ..	0.160	0.152	0.136	0.126	0.135	0.108	0.164	*0.161
% Calcium pectate in juice after 12 hours ..	0.161	0.150	0.101	0.051	0.100	*0.041	0.163	*0.157
% Calcium pectate in juice after 24 hours ..	0.158	0.149	0.073	0.012	*0.039	*0.010	*0.158	*0.151

* Indicates fermentation.

The thick consistency of plum juice causes great difficulty in its filtration. Even when a fresh juice is filtered several times an opalescence is noticed which detracts from the appearance of the juice. For this reason, experiments were devised to examine the action of pectinol at two temperatures in various proportions on plum juice. The material used was not pure juice, but had been somewhat diluted.

The tabulated data clearly indicate the general effect of the pectinol. The final effect was in all cases increased by raising the temperature of the juice. Clear juices were obtained from all the experiments in which pectinol was added, but it is necessary to state that to none of these cases could the term " brilliant " be applied. The juice was sufficiently clear to allow newspaper type to be legible when viewed through a jar with 3 inch depth of juice, but on holding the jar to the light, a decided opalescence was visible. The juice still retained this undesirable feature after filtration twice through a pulp filter.

The pectinol had a definite and progressive action on the pectins in the juice, as a study of the calcium pectate data reveals. The increased reduction in the percentage of calcium pectate obtained by the use of 2 per cent. pectinol as compared with that resulting from addition of 0.5 per cent. of enzyme was so small that it would appear unnecessary to add more than the latter amount.

Apple Juice.

The results of a series of experiments on the action of pectinol on apple juice are discussed in Part III of this series " Non-alcoholic Apple Juices."

Discussion.

An examination of the Tables shows that all the juices studied can be clarified to some extent by the use of pectin-decomposing enzymes. The effect is most clearly seen in the case of strawberry juice, possibly because in the other juices the high acidity may affect the enzyme action. In several cases, reasonable proportions of pectinol failed to affect appreciably the juice before fermentation commenced. This point is important for, when juices are being treated for conversion into non-alcoholic beverages, very little fermentation is allowable. In this connection it is unfortunate that the soft fruits mature during the hottest season of the year, when the rate of fermentation is naturally increased. In the case of very highly acid juices, clarification will probably be more successfully achieved by allowing a slight fermentation in the pulped fruit.

Results obtained with loganberry and raspberry juices indicate that, although pectinol may produce only slight visible alterations to the juice, its effect on the ease of filtration is considerably greater. Black currant juice that was unfilterable through a pulp filter, was filtered with ease after treatment with the enzyme, and similar experiences were noted with raspberry juice.

The data presented, together with results obtained on the larger bulks of materials, suggest that, where any fermentation is undesirable, pectin-decomposing enzymes may be successfully used to aid clarification and filtration.

Visible clarification cannot be taken as a measure of enzyme activity. In a few juices the enzyme produced a product brilliant enough to be decanted from its deposit and immediately bottled, but in the majority of cases the juices remained more or less hazy and the full effect of the treatment was not felt until filtration had commenced.

The appearance of slight deposits in the Seitz-filtered juices after several months' storage constitutes an undesirable feature of the use of pectinol. This can be obviated by pasteurising the juices at the enzyme inactivation temperature of 131°F. Most juices should not be adversely affected by this temperature, but its attainment introduces another process into the manufacture and is to be deprecated on this account.

In conclusion, it should be emphasised that the results obtained on the small samples of juices may not apply in all details to large bulks of materials. The experiments described in this paper have been intended as an introductory attempt to elucidate the general effect of enzymes on fruit juices, and the application of enzyme reactions to larger quantities of juices must be studied before any definite statements can be made concerning the advisability or otherwise of utilising such processes on a commercial scale.

Summary.

1. The nature of the colloidal constituents in fruit juices and methods for their removal are discussed. Chemical, physical and enzymic reactions are reviewed, with special emphasis on the latter.

2. An enzyme is described which decomposes pectin materials.

3. Experiments with a commercial enzyme preparation and various fruit juices are reported. Excellent results were obtained on strawberry juice, but with juices of higher acidity, such as loganberry, raspberry and black currant, considerable fermentation

occurred before any very noticeable results of the enzyme were apparent. Some degree of clarification was effected with all juices. The pectinol percentages were varied in each experiment, the figure which gave the best results being 1 per cent.

4. Evidence is adduced that enzyme action sometimes continues after filtration of juices through a Seitz sterilising filter, causing further deposits to form.

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INVESTIGATIONS ON FRUIT PRODUCTS.

III.—NON-ALCOHOLIC APPLE JUICE.

By Vernon L. S. Charley.

The present surplus of apples is largely confined to the culinary type of fruit and to this fact is due the considerable difficulties associated with its utilisation. The modern cider industry, with its increasing need for quantities of raw material, is at the moment an important outlet for "cull" fruit. But it must be emphasised that there is a definite limit to this channel for low grade fruit. Culinary apples alone do not make a very palatable cider on account of the characteristic features of the juices obtained. In the first place, these juices are low in sugar and tannin. The former deficiency is generally associated with lack of "body," whilst a low tannin content is associated with a lack of character and astringency so essential to a good quality cider. On the other hand, culinary apple juices generally possess very high acidities ranging from 0.9%—1.2%. The cider industry, requiring to sell a cider with an acidity of about 0.6%, has been accustomed to blend culinary fruit with bittersweet cider apples in roughly equal proportions, but the supply of English bittersweet fruit is now becoming so depleted that it is quite insufficient to meet this demand. The use of larger proportions of culinary apples is to be deprecated, for the resulting ciders will lack the quality and character which are so intimately associated with beverages made from genuine vintage varieties. It is thus clear that the cider industry cannot be regarded as providing an outlet for unlimited quantities of culinary fruit.

The production of non-alcoholic beverages from apple juice has been considered for some time as a possible outlet for surplus fruit, and the present paper, which is intended as an introductory one on the subject, deals with various aspects of this problem. The methods in use in countries where such juices are commercially prepared are also discussed and data obtained experimentally at Long Ashton with various culinary fruit are presented.

The question of the composition of juice is of primary importance. Not every variety of apple will, on suitable treatment, yield a palatable product capable of being consumed without previous blending. Alcohol-free drinks must be judged by different standards to those usually adopted for alcoholic beverages. The latter are taken as stimulants, whilst the former find favour largely as thirst-quenching drinks. A brisk somewhat penetrating acid character is very desirable, as the juice will contain practically all the original sugar of the fresh fruit in undiminished proportions. The question of sugar content raises a further point. Heavy juices such as Kingston Black or Woodbine among cider varieties will be too sweet for drinking alone, whether carbonated or not, and the higher sugar content will tend substantially to mask the acidity. On the other hand, culinary fruits often possess acidities greatly in excess of those consistent with obtaining the best results. The acidity of the final product should generally be between 0.7% and 0.8%, but this range must be regarded as being purely arbitrary, as various acids in apples possess very divergent flavours and powers of penetration. For this reason, each juice must be tested individually to ascertain what dilution and sweetening will be necessary. A few sorts of apples possess a sufficiently balanced analysis to be used for single variety juices. Amongst these are Newton Wonder, Allington Pippin, Wealthy, Lord Derby and Cox's Orange Pippin. Wellington, Lane's Prince Albert and Bramley's Seedling are examples of varieties too sharp for general use. It is possible to dilute such juices until the acidity is of the correct order, and subsequently to add sugar until a specific gravity of about 1.045—1.050 is obtained.

Any fruit which is not definitely attacked by moulds or bacteria causing acetification may be used. The presence on the apples of any considerable amount of mould will always prejudice the flavour of the beverage, imparting to it a disagreeable taste, and the presence of even very small quantities of mould in some cases are often sufficient to spoil large volumes of juice. If the fruits are badly broken, and rotting has commenced, bacteria with which the tissues will readily be inoculated will cause fermentation with the formation of acetic acid. This foreign flavour is as objectionable in an alcohol-free beverage as in one containing this substance. Apart from these qualifications almost any type and state of fruit may be used as the raw material for this class of beverage. Small, misshapen apples, badly scabbed material, or badly bruised fruit in which definite surface rots are not developed are suitable.

In an introductory paper of this nature it will be convenient to refer briefly to the various stages in the production of these

beverages, noting in particular, the literature bearing on the different processes. The preparation of clear apple juice may be divided into three main operations : (1) formation of a coagulum, (2) removal of deposit, (3) carbonation and bottling.

1. *Formation of a Coagulum.*

Direct filtration of fresh apple juice to obtain a clear product is quite impracticable on a commercial scale unless some previous treatment is adopted. Clear juice can be obtained by filtration through a pulp filter (as used for cider), but such small quantities are filterable before the pulp becomes completely clogged that the procedure is entirely uneconomical to carry out. The collodial material in apple juice is largely composed of protein and pectin aggregates, and the methods for their removal are based on delicate reactions which need careful manipulation. It may be given as an axiom for this work that it is much harder to remove undesirable constituents of the juice (i.e. sediment and slime) than it is to leave unaltered some of the desirable compounds (i.e. colouring matter, tannins). The methods to be used for inducing a coagulation of colloids must be reviewed in the light of this fact.

Seven main processes are in use, namely (*a*) heat, (*b*) chemical precipitation, (*c*) adsorption, (*d*) enzymes, (*e*) clarification at low temperatures, (*f*) clarification under pressure, and (*g*) slight natural fermentation.

(*a*) *Heat treatment.* The application of heat to a fresh apple juice causes a copious deposition of light flocculent precipitate which gradually settles down from the juice. The clear juice may be racked away from the deposit, but the treatment is so incomplete that considerable quantities of suspended matter are still left in the juice, giving it a milky appearance. With an efficient heat treatment, the racked juice can be subsequently filtered through a pulp filter to give a clear product. Should it be decided to use pasteurisation for the final sterilisation of the juice in bottle, it is necessary to heat the fresh juice to a higher temperature than that used for the final pasteurising treatment. The hot fresh juice (149°F.) can be preserved free from fermentation by storage in paraffined casks (1).

" Flash " pasteurisation is a modern development to obviate any danger of the presence of a " cooked " flavour in the juice. The fresh juice is run through a special pasteuriser designed to raise the temperature of the juice to 180°F. for 20 seconds ; the cooled juice running from the machine is mixed with some form of filter aid and immediately filtered through a plate and frame filter (2).

Pasteurisation at any stage of the processing of apple juice must be accompanied by careful tests to determine whether any deleterious effects are being produced on the flavour of the beverage.

(*b*) *Chemical precipitation.* Chemical methods all aim at the production of a diffuse, flocculent precipitate, which, in its downward progress through the bulk of the juice, will envelop, or occlude, the suspended material and carry it down with it.

Apart from the physical action of enveloping the slimy materials in the juice, the chemical added in many cases is electrically charged, and a precipitation ensues which is a direct result of neutralisation of the negatively charged colloids of the juice by the positive charge of the precipitant (i.e. gelatin) (3). It has been found that an excess of gelatin will instantly "protect" the coagulated colloids, and as a precaution against this tannin is usually added to precipitate any excess gelatin.

Gelatin, milk, white of egg, casein, blood, fish paste and a variety of compounds of similar nature have been used but, owing to the delicacy of the equilibria involved, very careful adjustment of the conditions is necessary. For example, should there be an excess of any added reagent, it will serve as a yeast food and fermentation will be the more probable. Most of this class of coagulants have distinctive and unpleasant flavours, and the slightest excess of any one of these will contribute to the ultimate destruction of that pure, fresh fruit flavour on which so much will depend. Finally, there is ample evidence to show that gelatin is almost as efficient a decolourising agent as a coagulant.

(*c*) *Adsorption.* The adsorbing properties of the surfaces of many compounds have been used for many years in a limited way, to purify and clarify a variety of food products, but here again, caution is necessary in their application to apple juice problems. Originally intended as decolourising and deodorising agents, their adaptation to the problem of fruit juices demands considerable care. Such great variation exists between the different preparations of fuller's earth, Spanish clay, and charcoals on the market that the use of any of these products must be attended by careful preparatory tests. At the present time, adsorption of the coagulum by this method is restricted by the above considerations.

(*d*) *Enzymes.* The use of enzymes has already been discussed in a previous paper of this series (Investigations in Fruit Products, Part II, this Report p. 202), and mention will merely be made here of various experiments appertaining to apple juice and pectinol.

an enzyme capable of rendering the insoluble colloidal pectous particles more soluble and the juice easier to filter. The composition of colloidal material in apple juice has been shewn to consist largely of proteins, pectins, and various carbohydrates. All three classes of compounds are complex in nature and impart a considerable degree of viscosity to any solution in which they may be suspended. Their complete removal presents many difficulties for the solution of which methods drawn from all branches of chemistry have been sought and widely discussed. Enzyme action has been applied to the clarification of apple juice since 1913, but very little success has attended the experiments until quite recently. Kertesz in 1930 published a method (4) for the decomposition of the pectin compounds in apple juice by an enzyme prepared from the mould, *Penicillium glaucum*. A minor portion of the pectin is precipitated, whilst the rest is made soluble and forms a true, and hence filterable, solution.

Enzyme actions are not instantaneous, but need appreciable periods for their completion. The time required varies inversely with the amount of enzyme used, and thus any given time can be halved by doubling the amount of enzyme, which affords a ready means of timing the operation. Using sufficient enzyme to complete the process in about 15 hours, Kertesz passed the juice through a centrifuge for a certain period " depending on the speed and the cider " and obtained a perfectly clear cider which could be bottled immediately. The method has received considerable attention in America, notably by Carpenter and Walsh (2). They used an enzyme, Pectinol, which was sold commercially, and was claimed to be identical with that described by Kertesz. The workers found that considerably greater quantities of enzyme than those stated to be necessary were essential to achieve successful results. After filtration through a pulp and sterilising filter and subsequent bottling, a light deposit, amorphous in form and free from yeast cells in living or dead condition, invariably formed. This is probably due to the continued action of the enzyme after filtration and bottling, and if it proves to be of general occurrence, will constitute a serious drawback to the method. Carpenter and Walsh describe experiments with a further enzyme, clarase which attacks pectins and tannins, thus reducing the colour and astringency simultaneously. The nutrient basis of clarase is malt extract, and the flavour of malt is discernable in the juice. Whilst this flavour may possibly not detract from the quality of certain products it is doubtful whether a pure apple juice would prove acceptable with this taint.

Marshall (5) studied the effect of various clarifications of apple

juice on the marketing of the product. Stores were established to secure test sales of apple juices clarified by various means, and comparision was made between the sales achieved by differing brands. Greatly increased sales were obtained with ciders clarified by the pectinol method. In these experiments it is claimed that the manufacture of sweet cider shows a considerably greater profit on the original fruit than would the sale of the fruit on the fresh fruit market.

(*e*) *Clarification at low temperature.* The use of low temperature storage for apple juice, during which natural or artificial clarification proceeded and fermentation was inhibited was noted in several large factories in Switzerland by the writer when visiting the cider districts of that country in the autumn of 1931. The fresh juice was stored in large vats and cooled to —2°C. (It was found that even at so low a temperature as 0°C. fermentation sometimes occurred). The juice was pumped off the sediment after an interval of several weeks, and then restored to the low temperature again until needed for bottling purposes. Artificial clearing was effected with 5 grams of gelatin per 100 gallons of juice. The cleared juice was usually left at —2°C. for 12 months before being carbonated and sold, as the lower temperature is said to produce a better flavoured beverage. The method is entirely dependant on a cheap supply of power to obtain efficient refrigeration and, in view of this, it appears unlikely that the storage at low temperatures of apple juice designed for the non-alcoholic juice trade would be a commercial proposition in this country at the present time.

(*f*) *Clarification under pressure.* An interesting method of arresting fermentation whilst clarification is being effected, was studied by the writer during the tour mentioned above. The juice was pumped into strong steel tanks of 10,000 gallons capacity and a top pressure of 120 lbs. per square inch of carbon dioxide applied. A light clarification by gelatin was used, and after a period of about 6 weeks a fairly clear juice was obtained, which, after the major part of the dissolved gas had been disengaged by a stirring machine, was filtered and bottled. The product was characterised by a clean, fruity, flavour and attractive colour.

(*g*) *Slight natural fermentation.* The majority of apple juices undergo a natural clarification during fermentation, and the more complete the fermentation the more satisfactory the clearing. For this reason, a slight fermentation materially aids clarification and filtration, but the process is one which needs careful regulation

on account of the production of alcohol. In this country a non-alcoholic beverage is allowed to contain not more than 2% proof spirit, i.e. 1% by weight of alcohol (1.26% by volume), and every precaution must be taken to prevent fermentation which would lead to alcohol in excess of this figure being formed.

The most convenient check is specific gravity. A drop in gravity of 10 points can be assumed to be indicative of the formation of about 1% alcohol (by weight). Hence, it is unsafe to allow the fresh juice to lose more than five or six degrees of gravity before filtration. But if attention can be given to ensure careful control of conditions, this slight fermentation can be of great use in destroying the slimy material in the fresh juice and, without in any way vitiating the desirable characters of the product, a considerable saving of time and labour can be thereby effected.

Fermentation will depend very largely on the condition of the fruit and on the temperature of the juice immediately after pressing. Badly bruised apples pressed during warm weather will be predisposed to a quick initial fermentation, whilst fruit pressed later in the season will be slower to commence fermenting and the reaction will be more easily controlled. The specific gravity hydrometer (or spindle) should be constantly in use if this process is adopted.

2. *Removal of Deposit.*

(*a*) *Filtration.* Filtration has always been the chief means of removing the deposited material from apple juice and, indeed, remains the most universal method to-day. A variety of filters are available, amongst which are the ordinary pulp filters similar to those in use for filtration of cider. It is the general custom to use a filter-aid of some description to prevent a too quick clogging of the pores of the filter-medium, and to lengthen the life of each packing of pulp. The remarks relating to adsorbent charcoals, etc., apply equally to materials suitable for filter-aid ; great care must be taken to ensure absence of taint or decolorisation resulting from the use of the diatomaceous earth (kieselguhr). A juice that has received an efficient clarification may be easily filtered without relying on a filter-aid, but in general routine it will be found advisable to use a fair quantity of this " baked " earth in conjunction with some form of plate and frame filter. Such a filter consists of a horizontal series of plates on which is prepared a layer of pulp and filter-aid. Cloths are generally used as a base to receive this mixture and are stiffened by resting on a wire mesh. The main bulk of filter-aid is thoroughly well mixed into the juice to be filtered, and the mixture pumped slowly through the filter.

There is a progressive removal of slime as the filter-aid is deposited on the cloths, and a thick coherent layer of filtering medium is built up. Considerably greater quantities can be cleared in this way than by the use of an ordinary filter, and filter-aids are on the market which are efficient and free from any suspicion of imparting foreign flavours to the juice.

(*b*) *The Centrifuge.* The centrifuge has been used to clarify juices and to remove the deposit from already coagulated products. Gore (1) using a milk separator stated that "the bulk of the insoluble material" was capable of removal in this way. But the juice remains cloudy after treatment, and it seems probable that the centrifuge will be more efficacious if used to effect a preliminary removal of deposit and then adopting further means to obtain a clear juice. The drawback associated with the use of the centrifuge for clearing fermented cider is that the issuing cider is always hazy, or in other words, the true colloidal material is not completely removed. It is natural that this difficulty should be accentuated with a fresh juice which has not undergone any clearing usually associated with fermentation, but as a means of quick and convenient removal of the greater part of the insoluble material the centrifuge possesses many attractions.

Kertesz (4) states that after treatment with enzymes for a certain period, apple juice can be centrifuged to a perfectly clear product which is ready for bottling. Unfortunately details as to speed of centrifuge, rate of inflow of juice, and amount of enzyme used are not stated.

Carpenter and Walsh (2) centrifuged fresh apple juice and analysed the deposit so obtained. The details are of interest and are reproduced here: 5 gallons of juice were taken of each of the 3 juices, Northern Spy, Rome Beauty and Russet. The centrifuged material was dried at 102°C.

TABLE I.

CENTRIFUGED MATERIAL FROM APPLE JUICE.

	Northern Spy	Rome Beauty	Russett
Dry materials in grams. ..	22.00	37.40	43.30
Ash %	2.80	4.85	5.50
Fibre %	4.24	2.66	2.80
Protein %	19.05	30.70	24.75
Pectose %	1.58	3.64	2.72
Pectic material %	33.02	24.00	22.80
Tannin %	1.58	1.46	0.96
Ether extract	8.19	6.57	5.06
Total Sugars	11.60	3.84	2.91
Total %	82.06	77.72	67.50

3. *Carbonation and Bottling.*

The carbonation of cleared apple juice is of definite advantage in bringing the delicate flavour of the apple into due prominence. With juices which would otherwise be too sweet carbonation affords a simple and effective means of introducing, in some degree, the brisk character which is indispensable in a good product.

The usual types of carbonator and bottler used in the cider industry are convenient for non-alcoholic apple juices, and methods of procedure and manipulation remain essentially the same. The juice may be passed through a sterilising filter previous to carbonation ; this necessitates extremely careful sterilisation of vessels, pipes, pumps and bottles, and 2% sulphur dioxide has proved eminently suitable for this purpose. If this method is not adopted, the bottled juices must be pasteurised at a temperature slightly below that necessary for an uncarbonated juice.

Experiments on Clarification and Sterilisation of Fresh Apple Juice.

A series of non-alcoholic apple juices were prepared in 1932 from cull fruits from the Research Station plantations at Long Ashton. The fruit was typical of the material usually associated with scabbed low grade material, but the quantities obtainable were small and the experiments were arranged accordingly. The fruits of the varieties Lord Hindlip and Ontario were badly bruised and in an unmarketable condition. In view of the necessity of providing controls for all the experimental treatments, the quantity of juice available for each experiment was small, and the normal apparatus used in the cider house for filtering, etc., was dispensed with and smaller laboratory material used. The juices were obtained by the large mill and press, and separated into 2 portions, one used as a control, the other treated either with pectinol or, in one case, gelatin. Pectinol was added at a rate of 30 ozs. per 100 gallons of juice, and thoroughly mixed with the juice. A 2 days' period was allowed for the reaction, when the control and treated samples were filtered through a small wine filter adapted for use with pulp packing. Each sample of treated and untreated juice, after filtration was bottled, either directly and pasteurised at 155°F. for half-an-hour, or Seitz filtered and collected in bottles sterilised with 2% sulphur dioxide solution.

Pasteurisation was effected by heating the bottle (doubly wired) in an autoclave (without pressure) the water present being sufficient to cover the bottles. The temperature was raised slowly to 155°F. during $\frac{3}{4}$ hour, and maintained there for $\frac{1}{4}$ hour. The bottles remained in the hot water until cool enough to be withdrawn by hand.

A small laboratory Seitz filter (2 litres capacity) was used for sterilising the juice by filtration through the germ-proof E.K. film. The apparatus was steamed out and 300 cc. warm water pumped through the pad, to remove any trace of flavour which might be due to the film. The juice was run through for a sufficient period before collecting to ensure obtaining a true sample.

The analyses of the fresh juices used were as follows :—

TABLE II.

	Specific Gravity	Acidity (as % malic acid)	Tannin
Bramley's Seedling	1.045	0.94	0.12
Mixed Culls	1.040	0.91	0.12
Newton Wonder	1.043	0.58	0.07
King Edward VII	1.046	0.77	0.09
Wellington	1.041	1.19	0.11
Lord Hindlip + Ontario ..	1.041	0.66	0.10
Allington Pippin	1.043	0.68	0.10

The details of colour, flavour, etc., are presented in Table III, whilst the chemical changes effected by the various treatments are shown in Table IV.

TABLE III.

EFFECT OF VARIOUS CLARIFYING AND STERILISING TREATMENTS ON A SERIES OF FRESH CULINARY APPLE JUICES.

Variety	Treatment of Juice	Method of Sterilisation	Colour	Clarity	Condition	Deposit	Flavour
Bramley's Seedling ..	1. Control	Seitz filtered	Light yellow	Quite clear	Still	Nil	Thin, lacking in body and aroma
,, ..	2. ,,	Pasteurised	Orange	Clear	,,	,,	Fair
,, ..	3. Pectinol	Seitz filtered	Light yellow	Very clear	,,	Slight	Lacking in flavour
,, ..	4. ,,	Pasteurised	Dark orange	Clearer than 2	Slight fermentation	Slight	Best flavour. Very fruity and attractive
Mixed "culls"	1. Control	Seitz filtered	Pale yellow	Brilliant	Still	Nil	Deficient in aroma & "body" but superior to 3
,, ..	2. ,,	Pasteurised	Slightly darker than 4	Slight haze	,,	,,	Good
,, ..	3. Pectinol	Seitz filtered	Pale yellow	Brilliant	,,	,,	Unpleasant
,, ..	4. ,,	Pasteurised	Dark orange	Clearer than 2	,,	,,	
Newton Wonder	1. Control	Seitz filtered	Pale yellow	Clear	,,	Very slight	Fair, but deficient in "body"
,, ..	2. ,,	Pasteurised	Dark red	,,	,,	Nil	Good
,, ..	3. Pectinol	Seitz filtered	Yellow	Clearer than 1	,,	Slight	Rough taste
,, ..	4. ,,	Pasteurised	Yellow	Clear	Slight fermentation	Slight	Slight "cooked" flavour
King Edward VII	1. Control	Seitz filtered	Pale yellow	Clear	Still	Nil	Poor
,, ..	2. ,,	Pasteurised	Dark yellow	,,	,,	,,	Good
,, ..	3. Pectinol	Seitz filtered	Dark yellow	,,	,,	Slight	Fair
,, ..	4. ,,	Pasteurised	Yellow	Brilliant	Slight fermentation	Slight	Slightly rough
Wellington ..	1. Control	Seitz filtered	Very light yellow	Clear	Still	Nil	Fair
,, ..	2. ,,	Pasteurised	Dark red	Brilliant	,,	,,	Good
,, ..	3. Pectinol	Seitz filtered	Light yellow	Clear	,,	,,	Fair
,, ..	4. ,,	Pasteurised	Dark red	Slight haze	Slight fermentation	Slight	Good
Lord Hindlip + Ontario ..	1. Control	Seitz filtered	Dark yellow	Clear	Very slight fermentation	Slight	Thin
,, ..	2. ,,	Pasteurised	Very dark yellow	Brilliant	Still	Nil	Good
,, ..	3. Pectinol	Seitz filtered	Dark yellow	,,	,,	,,	Good, but rather thin
,, ..	4. ,,	Pasteurised	Very dark yellow	Clear	Very slight fermentation	Slight	Good
Allington Pippin	1. Pectinol	Seitz filtered	Yellow	Brilliant	Still	Slight	Thin and lacking in bouquet
,, ..	2. ,,	Pasteurised	Very dark yellow	,,	,,	,,	Good
,, ..	3. Gelatin + tannin	Seitz filtered	Light yellow	,,	,,	,,	Fair
,, ..	4. ,,	Pasteurised	Yellow	,,	,,	,,	Good

TABLE IV.

EFFECT OF VARIOUS CLARIFYING AND STERILISING TREATMENTS ON THE CHEMICAL COMPOSITION OF A SERIES OF FRESH CULINARY APPLE JUICES.

Variety	Treatment of Juice	Method of Sterilisation.	Specific Gravity	%Acidity (as malic acid)	%Tannin	%Calcium Pectate
Bramley's Seedling ..	Control	Seitz filtered (S.F.)	1.051	0.71	0.10	0.0589
,, ,, ..	,,	Pasteurised (P.)	1.051	0.59	0.10	0.0849
,, ,, ..	Pectinol	S.F.	1.051	0.63	0.10	0.0293
,, ,, ..	,,	P.	1.047	0.57	0.10	0.0656
Mixed "Culls" ..	Control	S.F.	1.047	0.56	0.07	0.0200
,, ,, ..	,,	P.	1.045	0.57	0.09	0.0282
,, ,, ..	Pectinol	S.F.	1.045	0.58	0.08	trace
,, ,, ..	,,	P.	1.047	0.55	0.07	0.0280
Newton Wonder ..	Control	S.F.	1.040	0.59	0.08	0.0130
,, ,, ..	,,	P.	1.040	0.56	0.10	0.0565
,, ,, ..	Pectinol	S.F.	1.038	0.69	0.07	0.0043
,, ,, ..	,,	P.	1.039	0.60	0.08	0.0600
King Edward VII ..	Control	S.F.	1.044	0.84	0.12	0.0761
,, ,, ..	,,	P.	1.046	0.77	0.10	0.0880
,, ,, ..	Pectinol	S.F.	1.044	0.80	0.09	0.0208
,, ,, ..	,,	P.	1.038	0.82	0.09	0.0873
Wellington ..	Control	S.F.	1.052	0.66	0.08	0.0220
,, ..	,,	P.	1.052	0.66	0.08	0.0271
,, ..	Pectinol	S.F.	1.050	0.72	0.08	0.0140
,, ..	,,	P.	1.048	0.72	0.08	0.0235
Lord Hindlip + Ontario ..	Control	S.F.	1.039	0.65	0.10	0.0166
,, ..	,,	P.	1.039	0.64	0.10	0.0667
,, ..	Pectinol	S.F.	1.036	0.69	0.10	0.0073
,, ..	,,	P.	1.035	0.68	0.10	0.0684
Allington Pippin ..	Pectinol	S.F.	1.043	0.66	0.10	—
,, ,, ..	,,	P.	1.042	0.63	0.10	—
,, ,, ..	Gelatin + tannin	S.F.	1.043	0.68	0.09	—
,, ,, ..	,,	P.	1.043	0.62	0.07	—

DISCUSSION.

Comparison of the results given by the various processes with seven varieties of fruit indicate certain obvious and well characterised distinctions of considerable importance. In the first place, the pasteurised samples always showed a much deeper colour than the corresponding Seitz-filtered material. Colour in apple juice is generally associated with the so-called "tannin" content, for in vintage cider varieties the bittersweet fruit (i.e. high tannin content) usually afford the richest coloured juices. That tannin is not the only compound contributing to the colour would seem to be shewn by the fact that juices from culinary sorts, noticeably deficient in tannin, will give quite deep colours after exposure to the air. It is generally accepted that the formation of colour in apple juices is largely due to the action of an oxidase. The removal of colour by the Seitz filter is difficult to explain, and

yet the action was similar with all the samples tested. It is probable that the tannin complexes are colloidal in nature, and this action of the filter is one of adsorption. It has been shewn by Carpenter, Pederson and Walsh (6) that removal of the bacteria, etc., by the sterilising film of the Seitz E.K. filter cannot be accounted for by a simple sieve action, pores in the film being many times larger than the actual size of the cells removed. Adsorption would be a probable phenomenon when the nature of the film and the juice are considered together. In this case, it may be expected that with a prolongation of filtering no return of colour would be obtained.

If the removal of colouring material is entirely due to the film itself, it is possible that with large quantities of juice, a saturation point will be reached, after which a better coloured juice will be obtained.

In the experiments under discussion, small scale filtrations only were made, but the study of the decoloration will be extended to larger bulks of juice in next season's work.

The pasteurised samples, as a whole, possessed attractive golden colours, and in the case of the Allington Pippin juice a product with the rich golden colour reminiscent of a high-class vintage cider variety was obtained.

Turning to the question of flavour, it is clear that very definite differences are obtained when pasteurisation or Seitz-filtration are used.

The fresh fruit flavour was more distinct in the Seitz-filtered samples, whereas the pasteurised juices were, in some cases, notable for a " cooked " flavour which is associated with the effect of heat on apple juice. In cases where the " pasteurised " taste was not fully developed, it was observed that a flavour similar to the well-known " apple pie " character associated with certain ciders was present. The exact nature of the differences between the Seitz-filtered and pasteurised samples is somewhat difficult to define, for the latter possessed considerably more flavour and greater " body " than the corresponding Seitz-filtered samples. For the preparation of an apple juice in which the full, fresh fruit flavour is indispensable, it would appear essential to use some process which does not involve the application of heat to the juice.

An interesting feature of this series of juices was noted during a second sampling of the beverages to obtain data on flavour, etc. It was at once apparent that alterations in flavour were in progress. Whereas many juices had previously been found to be free from any " cooked " taste, after a period of 2 months' cellar storage a

definite and unmistakable pasteurised flavour was becoming prominent. It is possible that such changes may proceed for some further period, and may modify to a marked extent the above remarks concerning the juices.

The effect of pectinol is not so easily elucidated. In the matter of colour it appears that the pectinol Seitz-filtered sample is generally darker than the control juice, but, on the contrary, the control pasteurised sample was usually darker than the pectinol treated juice. It is definitely determined that in the majority of cases, pectinol improves the clarity of the product. In the cases where a slight diminution of colour was associated with the use of pectinol, the enhanced clarity more than compensated for the loss in colour. An important consideration in connection with the use of pectinol should be mentioned. In the small scale experiments carried out to obtain the data presented in this paper, it was noticed that filtration of the pectinol treated samples was much more easily effected than of the untreated juice. The effect was easily gauged by the use of a small wine filter which was constructed on similar lines to the pulp cider filter. The capacity was small, and after a certain period of filtration had elapsed the filtering medium commenced to become clogged with colloidal material from the juice. The pressure needed to force the juice through the filter gradually increased until a point was reached at which further filtration was negligible. The volume of juice filtered before this critical pressure had developed afforded a crude measure of the colloidal material in the juice. From such observations it appeared that the pectinol treatment had resulted in a considerable reduction in colloidal material, with a consequent improvement in filtration. This fact has obviously an important bearing on commercial practice, as it constitutes a real practical advantage. The filtration of a thick juice without doubt consumes time, labour and profit.

In several cases it was noted that pectinol samples possessed a slight roughness on the palate. Two possible causes for this may be mentioned. In the first place, the enzyme is prepared on some nutrient material (such as bran or pollard) and fixed thereon. It may be that this substance is capable of imparting a foreign flavour to the juice. On the other hand, it is possible that the rough flavour belongs inherently to the juice, but that the removal of pectous material associated with the loss in " body " of the juice causes the rough flavour to be more noticeable. Reference to Table IV, column 7, will illustrate the wide differences in pectin which are caused by the various treatments. These figures will be discussed later, and it is sufficient to emphasise here that the samples which are invariably of poor or only fair " body " and

flavour are those in which the pectin contents are low compared with the corresponding controls.

The data obtained for flavour and "hardness" on the palate tend to throw into relief the question of the effect of pectin on flavour and character of apple juice. Recent work in several Oenological Institutes in France has indicated very definite correlations between "velouté" (softness) and pectin content. This desirable character has been imparted to a wine seriously deficient in "body," by the addition of 0.04% pectin, and the increased character of wines from the Grecian Archipelago was shewn to be due to the warming of the whole "must" before pressing. This results in a decomposition of the pectose into sugars and simpler pectin compounds which are assumed to be responsible for the soft mellow flavour under discussion. (Semichon (7), Semichon and Flanzy (8)).

Warcollier (9) asserts that the "characters described as "l'onctuosité" and "la velouté," (equivalent to our English terms "bouquet" and "softness,") in ciders are dependent on the amount and nature of the pectic constituents present. High-class ciders should contain from 0.03—0.05% of pectic material.

In describing work on the enzymic clarification of unfermented apple juice, Kertesz (3) states as follows: "Since all colloidal materials are removed from the juice no precipitates occur during pasteurisation and there is no cooked taste afterwards." The flavour developed by pasteurisation at too high a temperature is here explained as the action of heat on the pectins, as the enzyme under discussion in the paper is specific in its action toward pectin compounds.

The work cited from French and American sources illustrates the importance of pectin compounds on the flavour of the product. It would seem that the retention by the juice of a certain quantity of pectin sufficient to bestow the desirable mellow flavour is essential. However, it will be necessary to investigate the question of the relative effects of pectin content on flavour and filtration to discover to what extent the reduction in pectin content of a juice may be allowed to proceed before the adverse effect on flavour is noticeable.

An interesting feature of the pectinol samples is the observation that in five out of the seven juices considered, slight fermentation had occurred in the pasteurised bottled juices. With the exception of a slight evolution of gas in the Seitz filtered control sample of Lord Hindlip and Ontario, these five cases were the only evidence of fermentation in the whole series. A slight deposit was associated with each.

A consideration of the chemical data in Table IV reveals several interesting features. The specific gravity figures are lower in the case of the pectinol samples, though the relation between the gravities for the pectinol Seitz-filtered and pectinol pasteurised juices is not similar for the various varieties ; in five out of the six direct comparisions of pectinol treated and untreated juices, the pectinol pasteurised samples were lower in gravity. This is in accordance with the observations on the incidence of fermentation in the juices.

Acidity and tannin data do not show any definite correlations with the treatments applied to the juices, but very large differences are found in the determinations of calcium pectate. Two main divergences are at once apparent. The calcium pectate percentages are very much greater in all the pasteurised samples than in the corresponding Seitz-filtered material, and the pectinol treatment has resulted in a further diminution of pectin. An outstanding example of the first type is in the Newton Wonder juice, where the Seitz-filtered pectinol-treated juice contained only 0.0043% of calcium pectate, whereas in the pasteurised sample 0.060% was found, a fourteen-fold increase. But whilst the example quoted is an extreme case, the figures do show that large differences in pectin content are caused in the respective processes of Seitz filtering and pasteurisation. The figures receive added interest when considered in association with the data for flavour, and it will be seen that a close parallelism exists between the softness of flavour and " body " of the juices and their percentages of pectin.

It may be appropriate at this point to mention briefly the general characters of the various juices made during the experiments, more with reference to their palatability and relative importance as prospective commercial products than with regard to the scientific issues involved. The chief desirable property in a non-alcoholic juice is probably its thirst-quenching properties and in this connection acidity plays an important part. The higher the acidity of the juice, the more attractive it appears from this particular point of view. Wellington juice, even after 50% dilution with water and subsequent sweetening, was a pleasant drink, whilst Newton Wonder fruit, in bad condition and small and misshapen in size, gave a juice which possessed a full fruity flavour, which in addition to its clear golden colour, made this product very attractive.

The mixed culls fruit consisted of a sample taken from a large bulk of Irish fruit, 70% Bramley's Seedling and 30% poor quality cider fruit. The sample contained a high percentage of rotted specimens, but the usual cider making process of washing the fruit preliminary to milling and pressing was adopted to eliminate the

rots. The juice prepared from this material was very attractive in flavour, aroma, and colour, and its superiority to juices made from fair quality Bramley's Seedling culls alone is of interest, showing as it does the effect of mixing even small quantities of vintage fruit with the culinary types.

The juice from King Edward apples was not so fully flavoured as others, but possessed definite possibilities as a commercial product, whilst Allington juice, prepared from very small fruit, was notable for its delicate aromatic bouquet.

Preliminary trials with the Centrifuge for Preparation of Non-alcoholic apple juice.

Some experiments were made to investigate the degree of clarification obtained by passing freshly pressed apple juice through a commercial centrifuge. The trials were of a preliminary nature, and only brief mention will be made here of their general design and the tentative results produced.

The machine used was a Sharples Supercentrifuge, capable of giving 16,000 revolutions per minute. This maximum speed was consistently used throughout the trials. The juice was fed into the machine by a pump at an approximate rate of 100 gallons an hour, this being the normal rate for cider. The juice was collected in a carefully sterilised vessel and immediately filled into the various storage vessels required.

The juice used for the trials was obtained from mixed apples from Monmouthshire, having the following analysis: specific gravity 1.047, acidity (as malic acid) 0.52%, tannin 0.19%. Three 120 gallon casks of juice were taken for the experiment, and maintained at a temperature of 10°—12°C. 1½ lbs. of pectinol was added to one cask and thoroughly well mixed into the bulk of the liquid. After 20 hours, the following operations were carried out: 30 gallons of each of the control and treated juices were centrifuged under the conditions stated above. Samples of the juice were collected in glass gallon jars, these being of convenient shape and depth for comparing differences in clarity. The remainder of the centrifuged juice was then filtered through the usual pulp cider filter. Further quantities from the initial bulk of juice were filtered direct from the cask. The centrifuged material from the pectinol-treated and control casks was quite opaque in appearance with a slight advantage in favour of the treated material. Ordinary pint bottles made in white glass when filled with centrifuged juices were quite opaque and apart from removal of solid material, very little change in the appearance of the juices was apparent. The centrifuged juice was easily filtered through a pulp filter, a brilliant product

being obtained, and a large amount of juice was filterable through a single packing of the filter. The untreated portion of the juice, after filtration through the usual type of filter, was perfectly bright, but very small quantities of such juice were obtainable. These preliminary trials shew the use of the centrifuge in aiding the output of a pulp filter, but it does not appear that the use of a centrifuge alone under the conditions mentioned above is likely to afford a brilliant juice ready for immediate bottling. Further trials on the effect of the speed of the centrifuge and other practical problems will be carried out during next season.

Summary.

1. Various methods for the production of non-alcoholic apple juice are discussed.

2. Experiments are described which illustrate the effect on flavour, colour, and chemical constituents of clarifying and sterilising processes.

Filtration through a germ-proof filter is shewn to affect adversely the " body " and colour of the juice.

A pectin-decomposing enzyme is described and its action on the juice and the resulting increase in clarity and loss of " body " are discussed.

The changes in pectin in the juices are given in terms of calcium pectate, and the correlation between lack of flavour and loss of pectin is indicated.

The general nature of the juices prepared from " cull " sorts of culinary apples is discussed and the products shown to possess attractive characters.

3. Preliminary experiments with the centrifuge as a means of clarifying cider are discussed.

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THE PREPARATION OF "WHITE RODS" BY FORCING METHODS.

Progress Report.

By H. P. Hutchinson.

In March, 1931, a Birmingham willow merchant drew the writer's attention to the fact that newly peeled white willows had been imported from Germany in February of the same year.

An examination of a sample of these willows which was sent to the Station showed that the rods had been recently peeled, probably in the previous January. They were of the *S. triandra* species, none of the varieties of which are peelable in this country under ordinary conditions until April or May.

Although white rods will retain their colour for many years, freshly peeled rods possess a lustre which renders them more attractive and consequently more readily purchased by basket makers than older rods. Hence, if the grower could adopt methods which would advance the peeling season, he would secure the advantages of :—

(*a*) Countering the advantage which forced willows give to the foreign producer.

(*b*) Marketing a greater number of peeled willows per season.

(*c*) Using his labour in a more economic way.

(*d*) Obtaining a financial return on his capital in shorter time.

The idea of forcing the growth of willow rods in order to secure early white has been considered by willow growers in the past, but the late Mr. W. P. Ellmore, of Leicester, appears to have been the only English grower who has attempted a practical exploitation of the idea. About the year 1900, he constructed a concrete bed into which willows were packed exactly as in the case of pitting willows in the open. Warm water—the waste from a factory—was permitted to flow through the bed. The factory water varied considerably in temperature and no attempt, beyond the construction of a roof, was made to control the temperature of the air. The result was that some of the rods became peelable a month before those in the open pits, a number remained dormant and a

considerable number died. The results did not justify further trials of the method.

Experimental.

Bolts of 25 varieties of willows, each containing from 200—300 rods, were placed in the greenhouse with their butts in water to a depth of 8 inches on 15th January, 1932.

The varieties taken were: Newkind, Glibskin, Pomeranians, Black German, Black Maul, Whissender, French, Black Hollanders, Grizette, Dutch, Champion, Mottled Spaniards, Brown Merrin, Mealy Top, Continentals, Clay Rod, Longskin, Dicky Meadows, Green Dicks, Harrison, Mawdsley, Red Root, Rouge d'Orleans, Violets, and Americana.

The temperature of the house ranged from 50° to 60° F. throughout the experiment. The supply of water was maintained at constant level by additions from the inside tank.

The order in which the several varieties became peelable, with supplementary notes taken at the time, is as follows :—

Date.	
Feb. 15th.	*Black Hollanders* (*S. triandra*), peeled freely throughout their lengths.
„ 19th.	*Clay Rod* (*S. viminalis*), variety in leaf. Catkins were not out.
„ 20th.	*Champion* (*S. triandra*). Variety in leaf. Shoots up to 12 inches long. Catkins not fully grown. Roots 6 inches long.
„ 22nd.	*Newkind* (*S. triandra*). This variety was from the first in advance of all the rest in shoot growth. Except for the basal 10 inches it was peelable on February 14th. At time of peeling roots were 9 inches in length and numerous. Catkins were fully formed but flowers not open.
„ 22nd.	*Brown Merrin* (*S. viminalis*) showed irregularity in shoot development, some buds being just burst, others grown into shoots 2 inches long. Stamens were fully out in some cases, in others catkins were in pussy stage. Roots up to 3 inches in length, less numerous than in case of Newkind. Those rods peeled most readily which had most leaf or with greatest number of buds starting to burst.
„ 22nd.	*Glibskin* (*S. triandra*). The variety peeled freely and was in full leaf; roots were up to 6 inches in length.
„ 22nd.	*Mealy Top S. viminalis*). In leaf and ripe catkin stage. More roots than in case of B. Merrin, but did not peel so freely.
„ 22nd.	*Continental* (*S. viminalis*). Very leafy. Shoots 1 inch long. Rooting freely. Peeled more freely than either Mealy Top or Brown Merrin.
„ 23rd.	*Daphnoides* (*S. daphnoides*). Small leaf development and small roots. Bark was thick. Peeled freely.
„ 23rd.	*Red Root* (*S. purpurea x*). Leafy. No flowers present. Was well rooted.

Date.	
Feb. 24th.	*Longskin S. viminalis*). Few leaves were open, but many buds were at bursting stage. The root development was small. Peeled freely.
„ 24th.	*Harrison* (*S. purpurea x*). Little leaf development. Buds bursting. Root development was small.
„ 25th.	*Mottled Spaniard* (*S. triandra*). 10% of the rods were dead. The rest were in full leaf. No flowers were present. Roots were well developed.
„ 29th.	*French* (*S. triandra*). Leafy on short stalks. More lower buds were started than in any other variety.
Mar. 1st.	*Mawdsley* (*S. purpurea x*). Leafy, well rooted.
„ 4th.	*Grizette* (*S. triandra*). In full leaf. No flowers.
„ 6th.	*Whissender* (*S. triandra*). Leafy. Roots were well formed. No flowers present.
„ 6th.	*Black Maul* (*S. triandra*). Leafy. Roots were well formed. No flowers present.
„ 12th.	*Rouge d'Orleans.*
„ 12th.	*Dutch* (*S. triandra*). Leafy and well rooted.
„ 12th.	*Americana* (*S. americana*). Little leaf. Poorly rooted. Thick barked.
„ 12th.	*Pomeranians* (*S. triandra*). Leafy and well rooted. Thin barked.

A few rods in each variety, mostly the small, were still dormant or dead at the time of peeling, but their number was insignificant. The " white " obtained was satisfactory in colour and quality for the respective varieties and was indistinguishable from " white " obtained in ordinary practice.

Note on Black German.

The bolt contained 225 rods, 4—8 feet long. On examination it was found that 48 rods had not rooted. A few buds had opened on the remaining rods but the leaves had turned yellow and died. The roots on the latter rods were short and were mostly dead. In many cases the rods had commenced to die back from the tips.

The result confirms practical observations which have been noted in regard to this variety, viz. that it " peels badly from the pit."

A PRELIMINARY INVESTIGATION ON THE PREPARATION OF RODS OF SALIX PURPUREA AS "WHITE."

By H. P. Hutchinson.

Rods of all varieties of the species *S. purpurea* are of great commercial value on account of their toughness, fine tapering growth and freedom from side shoots. They are used as "brown," which is merely the air dried unpeeled rod, or in the peeled condition as "buff."

Considerable expense is incurred in preparing such purpurea varieties as Red Buds or Dicky Meadows as buff; a boiling of the green rods for 3 or 4 hours is required before the bark can be removed, and, immediately afterwards, a month or six weeks' exposure to sunlight with frequent turnings must be allowed before the rods are ready for storage.

In the past it has not been possible to prepare rods of the *S. purpurea* species as "white." The usual methods of whitening adopted in the cases of the species *S. viminalis* and *S. triandra* if applied to rods of the *S. purpurea* species result in the formation of dark colouring matter which stains the wood, particularly in the regions of the buds and the apical portions of the shoots, to such a degree as to render the rods unfit for the basket makers' use. The presence of such discoloration is a characteristic of this species. It is also present, but in a less intense degree, in its hybrids with non-discolouring species and is said to be due to the presence in the plant of organic compounds which readily decompose when liberated from the plant tissues. In the presence of air, oxygen is absorbed with the rapid formation of dark coloured matter.

The stains formed in the wood are fast and become deeper with age and prolonged exposure to air and cannot be removed by any known means which would not at the same time seriously impair the quality of the rod.

Stone-rod or Stone-osier—a variety of *S. triandra*—is the only variety which approximates to Dicky Meadows, the chief variety of the *S. purpurea* species, in size and quality of rod. It is capable

of being prepared as first-class " white." But this variety is particularly difficult to grow satisfactorily owing to its great susceptibility to insect attacks and to its partiality to particular soil conditions. The basket maker needing small " white " for his work is compelled generally to use the small rods drafted from large sizes. The objection to this course is that such rods are of inferior quality since they are the undergrowth of tall growing varieties. Hence if Dicky Meadows could be produced as " white " an important want in the basket making industry would be satisfied.

It has been observed that if freshly peeled green rods of any variety of *S. purpurea* are wiped immediately after peeling, the darkening of the wood after drying is reduced in intensity. From this observation it seems obvious that a rapid and complete removal of the sap adhering to the wood should be sufficient to achieve the object desired.

Experimental.

A bundle of rods of the variety Dicky Meadows was cut in January 1932 and placed with the butts in water in a greenhouse, the temperature of which ranged from 50°—60° F. during the 24-hour day. On April 1st the rods were freely peelable.

Set A. 20 rods were taken from the bundle and after each was peeled it was immediately immersed wholly in tap water and allowed to remain there for 20 minutes.

Set B. 20 rods were peeled and wiped with cloth.

Set C. 20 rods were peeled and given no further treatment.

Sets A, B and C were allowed to air-dry for 24 hours.

Results.

The immersed rods (A) dried unstained excepting the bud centres which showed as small black spots. As " white " they were inferior to the best *triandra* rods but were satisfactory and marketable in this colour.

The wiped rods (B) were smeared with discoloured streaks and unsatisfactory as " white."

The rods (C) were much discoloured and unsaleable as " white."

Thus the simple method (A), which merely consists of an immersion of freshly peeled rods of *S. purpurea* in water, may eventually enable growers to market rods of this species as " white " and basket makers to meet the public taste in producing small basketry in first quality " white " as well as " buff."

REPORT ON ADVISORY WORK, 1931-32.

Recent reports of the advisory activities of the centre have shown continuous expansion of the work in all sections, but, during the past two or three seasons, it has become evident that the point has almost been reached when further increases will not be possible in the numbers of enquiries which can be dealt with by the officers responsible for the various subjects.

In the present instance, it is thus not surprising to find that the increases recorded are only notable in special cases. It seems apparent that in the future the volume of work may be expected to remain fairly near the present level, since a falling off would not be anticipated whilst appreciable expansion will be impossible.

In previous reports it has been customary to present statistics relating to enquiries of those sections for which numerical data have been available for six seasons, but, in the present review, this method has not been followed since, during the past two years, two new subjects have been added which will no doubt form important sections of the work in the future and for which it thus seems desirable to include details without delay.

In the table of statistics presented below it has not been possible to include figures for the usual section relating to " Disease Control Materials and Methods," owing to the prolonged illness of the officer who normally is responsible for this line of work.

In considering the contents of the table, and especially in comparing the figures for the current year with those of previous ones, it should thus be borne in mind that, in the present season, numbers for the new sections Veterinary Science and Domestic Preservation of Fruit and Vegetables, giving 290 and 224 enquiries respectively, are included whilst the section on Disease Control Materials and Methods, which contributed 142 enquiries in 1931, is not considered.

When these facts are taken into account the net increase for the year is 418.

The numerical data do not refer to Economics as that section does not deal with enquiries in a manner comparable with the others, the officers concentrating their activities on groups of farmers forming suitable economic units for studying special problems. This manner of working will be clear from the sectional report of the officer responsible for the subject.

Of the ten subjects for which figures are available for the years ending 1931, 1932, the only increases of importance which are shown relate to Agriculture and Agricultural Chemistry (+ 52), Cider (+ 82) and Economic Entomology (+ 212), and the only notable decrease is in Domestic Preservation of Fruit and Vegetables (— 47).

In the case of Agriculture and Agricultural Chemistry, such increases may be expected according to seasonal conditions, whilst in the cases of Cider and Economic Entomology the increased numbers are due to special circumstances.

Thus in Cider large numbers of enquiries are due to developments under the National Mark Scheme and the continued rapid expansion of the industry, whilst in Entomology, the special problems of the control of the raspberry and loganberry beetle and of the apple sawfly, and the continued interest in winter washes have been responsible for a large volume of work.

The significant decrease in Domestic Preservation enquiries is due to the fact that the Instructress in this subject has taken special measures to decrease the number by arranging classes at various centres, and thus effecting economies in dealing with the advisory side of her activities.

The following table summarises the numbers of enquiries submitted during the last six seasons :—

	Year ending September 30th.					
	1927	1928	1929	1930	1931	1932
Gloucester (including Bristol) ..	208	229	230	365	414	871
Hereford	115	100	118	137	159	169
Somerset	307	336	325	482	553	578
Wiltshire	143	206	235	219	265	343
Worcester	168	162	148	256	323	399
Other Areas	478	495	721	1025	919	960
	1419	1528	1777	2484	2633	3320*

* Includes Veterinary Science and Domestic Preservation of Fruit and Vegetables not previously included, but does not include Disease Control Materials and Methods included in 1931.

The figures under " other areas " include enquiries received from Devon and Monmouth, both of which contribute annual grants to the Long Ashton Institute, and from Dorset, which participated in the Scheme for Local Instruction in Cider-making until March 31st, 1932.

None of these counties rank officially as part of the Bristol Province, though an arrangement is in force whereby Monmouth is recognised as part of the Bristol Province for advisory purposes relating to Horticulture.

The data do not include the numerous enquiries dealt with in personal interviews during survey work, local investigational work, shows, etc.

The following features referred to in the sectional reports which follow call for special mention.

Agriculture and Agricultural Chemistry.

The number of requests for advice has again shown an increase over those for the previous year, especially in connection with the manuring and liming of arable land, and the composition of feeding stuffs for all classes of livestock. In this connection the collaboration between the agricultural officer and the manufacturers of feeding stuffs in Bristol and district has extended considerably.

The sugar beet investigations conducted by the Advisers in Chemistry and Economics, which have been in progress in the Province for the past six years, have provided the Advisers and County Agricultural Organisers with such information with regard to the growing, harvesting and storing of the crop as enables them to give farmers advice of direct practical value.

Experiments to determine the usefulness of sodium chlorate in the control of weeds have been recently concluded. These have shown that the chemical applied either broadcast or in solution is effective against couch grass and creeping bent, but is almost useless in the control of docks, bindweed and other deep rooting weeds.

The grassland investigations referred to in previous reports have been to some extent modified and considerably widened in scope as the result of a special grant from the Agricultural Research Council. Grants for these investigations are also gratefully acknowledged from the Bath and West Society, Messrs. John Robinson and a private donor. So far as the West of England is concerned, the data obtained indicate that the herbage of many of the pastures has a relatively high feeding value during certain of the winter months and contributes appreciably to the ration of animals which are grazing on these pastures, even if only for a limited part of the day. This is more especially the case with sheep. A comprehensive survey of the Teart grasslands of Somerset has been commenced and a team of workers, including the Advisers in Chemistry and Veterinary Science, a Soil Surveyor and a Botanist will be engaged upon this very important investigation.

In view of the increasing importance of poultry, a study is being made of the effects of folding poultry on grassland on the chemical composition of the herbage.

Problems are being studied in connection with the preparation and use of grass silage made in the stack, and the nutritive value of such silage compared with that of grass and hay produced from the same area.

The trial centre established on the Marlborough Downs under the scheme of the Pasture Sub-Committee of the Development Commissioners has been continued, and a botanical analysis made this year has shown the striking changes brought about in the herbage, as the result of a system of intensive manuring and frequent cutting.

It is hoped to issue shortly a report on a soil and utilisation survey which has just been completed of the Lower Greensand area between Devizes and Calne, in Wiltshire. The survey refers especially to the market garden industry within the area and its possible extension in the district.

Dairy Bacteriology.

The Dairy Bacteriologist has resumed his studies of the thermophilic organisms of milk and he is also conducting experiments with the Methylene Blue Reductase Test in combination with the test for coliform organisms with a view to obtaining a simple and relatively cheap method of examining milk for cleanliness.

Agricultural Economics.

The work in Agricultural Economics has been slightly modified during the year under review and more attention has been paid to economic surveys of special industries, such as willow growing and strawberry culture. Surveys of the poultry and dairy industries are being conducted in collaboration with officers in other Provinces. The analysis of simple financial accounts has been proceeded with, and has continued to provide farmers submitting these accounts with valuable information regarding their systems of management. The Wiltshire Agricultural Accounting Society has maintained an active membership of 55 farmers who regularly submit accounts. This Society has been in existence for $6\frac{1}{2}$ years and during that period it has operated very satisfactorily.

Veterinary Science.

Although the Adviser in Veterinary Science has spent much time on the examination of post-mortem specimens and the issuing of advisory reports, he has also given considerable attention to investigations of the prevalence of worm infestation in sheep and its control, anaemia in young pigs, and the incidence of Jöhnes

disease. In dealing with all his enquiries, the Adviser has worked in close co-operation with the local practising Veterinary Surgeons, and it is gratifying to record the number of requests for advice that the Adviser has received directly from the practitioners in the Province. From the experience gained to the present time there is ample evidence of the need for and value of local investigations of diseases prevailing in the West of England.

Economic Entomology.

The services of the Adviser in Economic Entomology have been in exceptionally large demand during the year, as will be realised from the large increase in enquiries received (+ 212). This increase is largely due to the special importance at the present time of problems relating to winter washes, and the control of the Raspberry and Loganberry Beetle, Apple Sawfly and Red Spider. The Raspberry and Loganberry Beetle has commanded serious attention in view of the demand for beetle-free fruit by the canning industry. A large programme of experiments to test the efficacy of preparations of derris, Pyrethrum and kerosene was carried out by the Adviser, and the results have shown that the most efficient control is obtained with derris-soap suspensions, such washes yielding entirely satisfactory commercial results.

Careful experiments were also carried out with the object of controlling Apple Sawfly which has become a serious pest in the Province during the past few seasons, and these have shown that substantial control can be effected by accurately timed nicotine washes.

Economic Mycology.

Advisory work in this subject continues to cover a very wide range of crops, including fruit, vegetables, hops, willows, and miscellaneous agricultural and glasshouse crops.

Excellent progress has been made in the special investigations on vegetable diseases and several important practical results have been secured. A point which requires special mention is that many of the diseases found are either entirely new or new to England.

Downy mildew of hops has threatened to become a serious menace in the hop growing areas of the Province during the past two or three seasons, and in order to meet this situation, a campaign to demonstrate methods of control was organised during the season in conjunction with the Ministry's Inspector for the area, Mr. C. E. Pearson, and the County Officers for Herefordshire and

Worcestershire. The results were entirely satisfactory and it may be said that growers are now familiar with the control measures necessary to combat the disease.

Considerable time was again devoted to diseases of basket willows, especially to the biology and control of willow canker.

Several new diseases of ornamentals were also recorded.

Willow Growing.

The chief feature of the year has been the formation of an Association of Willow Growers in Somerset with the object of maintaining the position of English rods in the home markets against the competition of imported willows. The marketing activities of the Association have demonstrated the importance of disease control, especially of rust cankers, and in view of this special attention is being given to spraying problems.

The subjects now covered by the advisory work of the Department are Agriculture and Agricultural Chemistry, Dairy Bacteriology, Agricultural Economics, Veterinary Science, Cider and other Fruit Products, Pomology, Horticultural Chemistry, Economic Entomology, Economic Mycology, Disease Control Materials and Methods, Domestic Preservation of Fruit and Vegetables, and Willow Growing.

The salient features of the work under each of these during the year are summarised below.

Agriculture and Agricultural Chemistry.

In view of the difficulty of differentiating between advisory work that may be strictly classified as "Agricultural" and that covered by the title "Agricultural Chemistry," the two aspects of the Adviser's work are considered together. The number of requests for advice under these two headings has again shown a further increase, more particularly in connection with grassland, farm livestock (including poultry), rationing and the utilisation of local supplies of limestone. Reference was made in the previous report to the requests for advice concerning the composition of balanced rations for cattle, sheep, pigs and poultry received from manufacturers in the Province, more especially in the City of Bristol. Further requests of this type have been received during the year under review and now nearly all the manufacturers of cattle foods in Bristol are in touch with the Department.

As the result of financial assistance from the Agricultural Research Council, a grant from a well-known local cattle food manufacturer

and a contribution from a private donor, it has been possible to extend considerably the University's work on grassland.

As in former years specimens of weeds and herbage plants have been received for the purpose of identification and report as to commercial value, poisonous properties, etc., and the co-operation of the Department of Botany of the University in this work is again readily acknowledged.

During the year ending September 30th, 1932, 371 requests for advice were received, which is an increase of 52 over the previous year. 515 samples were examined in the laboratory, and 210 advisory visits were paid.

A few notes on some of the samples received are appended :—

Samples of " hair " from a local tannery have been examined for agricultural value. The hair from hides is scraped off immediately after treatment with lime and water in tanks. This material when dried has been found to contain 20.7 % lime (CaO) and 8% nitrogen, and preliminary tests made under laboratory conditions indicate that it can be dried and ground into a very satisfactory type of fertiliser which should be of considerable value in market gardening areas.

Increasing attention is being paid to the quality of Cod Liver Oils used for feeding and veterinary purposes.

Samples of ground limestones from local supplies have been examined in the laboratory and field trials on grass and arable land with some of them have been put down in conjunction with certain of the Agricultural Organisers in the Province. The fine limestone dust from the Bath Stone Quarries has already given very promising results in grassland trials. It is now being marketed at a very reasonable rate for agricultural purposes, as are certain other limestone dusts in the Province.

The main investigations in progress or completed during the year were as follows :—

(1) *Grassland.*

As the result of a grant provided from the funds of the Agricultural Research Council and generous donations from other sources, and in view of the number of samples of herbage collected and analysed during the past six years, a revised programme of grassland investigations was drawn up early in the present year, and special attention is now being paid to the following :—

(i) The nitrogen metabolism of certain herbage plants, including wild white clover.

(ii) The effect of different systems of manuring and management on the chemical composition of grass.

(iii) The effect of season, manuring and management on the lime and phosphoric acid status of herbage.

(iv) The feeding value of winter grass.

(v) The effect of continual cutting and nitrogenous manuring on the botanical and chemical composition of Down herbage (for this purpose the plots originally established at the request of the Development Commission are being continued).

(vi) The comparison between the yield and composition of grass converted into stack silage (with and without chemical treatment) and hay.

(vii) The chemical and botanical composition of grass from the Teart lands of Somerset.

These investigations have not yet proceeded far enough for many conclusive results to be available, but the data obtained indicate : (*a*) during some of the winter months the herbage from certain of the West of England grasslands provide material that is relatively high in feeding value ; (*b*) the liming of acid pastures is essential to increase the lime content of the herbage ; (*c*) the productivity of grazeable dry matter from Wiltshire Down herbage can be increased by over 200% with suitable manuring, but such treatment after a continuous period of 3 years has considerably altered the botanical composition of the herbage as shown by the increases and decreases (calculated on the basis of the area originally covered by each species)—fine leaved sheeps fescue increase 60%, plantains increase 14%, legumes decrease 50%, other herbs decrease 80% ; (*d*) there appears to be a correlation throughout the whole of the season between the total crude protein and the " true " protein of herbage from natural pastures that have not been intensively stocked and manured, but it is difficult to trace any such correlation in the herbage from " intensive " grass.

It has been found that the folding of poultry on relatively poor Down grassland at the rate of 25 adult birds per acre per annum (the birds being penned on a small area each day and the pens moved daily), has produced a remarkable improvement in the herbage both in appearance and chemical composition.

A preliminary survey of the Teart area has provided the following information :—

(i) Sheep and cattle are affected.

(ii) " Teartness " is worse from May to July, and September to October.

(iii) It is impossible to rear stock on Teart land.

(iv) Scouring commences about 10 days after stock have been put on to a teart field, but ceases almost immediately after removal to " weaker " pastures.

(v) The feeding of hay or cake and corn is necessary throughout the whole of the season.

(vi) Leaving the herbage to become rough and coarse before feeding reduces its " teartness "—so also does frost.

(vii) The herbage of " teart " fields as judged by botanical composition is very good.

The problems of teart land are now being investigated in collaboration with the Adviser in Veterinary Science, a Soil Surveyor and a Botanist.

(2) *Arable Land.*

Field experiments on weed control conducted with sodium chlorate have proved that this chemical applied at the rate of 2 cwts. per acre in the autumn (either broadcast or in solution), will kill couch grass, creeping bent grass and buttercups and to some extent creeping thistles, but docks, dock seed, bindweed and deep rooting weeds are unaffected. In conjunction with the application of the chemical the usual cultural operations for weed eradication are necessary. The treatment had no apparent adverse effect on the succeeding crop of potatoes.

In view of the striking results obtained in 1931 with basic slag as a phosphatic manure for the sugar beet crop on acid land, the experiments have been repeated during the current year, and at one centre similar results have been obtained. A report on the experiments conducted in 1931 was published in the Journal of the Bath and West Society, Vol. vi., 1931-32.

A soil and utilisation survey of the Lower Greensand area of Wiltshire, occurring between Calne and Devizes, has been completed during the year. Part of the area, particularly around the parish of Bromham is devoted to market gardening. The survey has shown that soil and other conditions exist outside the actual Bromham district which are very favourable to the development of the industry over a considerably larger area. This work has been carried out in collaboration with the Agricultural Organiser for Wiltshire, and it is hoped to publish a report in the near future.

Dairy Bacteriology.

(1) *Enquiries and Advisory Work.*

Following the general upward trend in the number of enquiries and requests for advice received by the Dairy Bacteriologist each year since the commencement of the section, the number of such enquiries during the period under review shows a slight increase on the number received last year.

In all, 236 requests for advice have been received and 4,080 samples examined in the laboratory.

An increasing number of enquiries has been made by personal calls at the laboratory on the part of those seeking advice, and in such cases particularly it has been found possible to give all the assistance needed, the results of such advice being checked, where necessary, by a series of " advisory " samples, which the farmer was asked to submit over a short period.

In the past, enquiries have come mainly from the larger milk producers, and it is gratifying to note that an increasing number of small farmers are taking advantage of the Advisory Service. This is probably due in a very large measure to the Clean Milk Competitions, in which there are classes for small herds. Many of these producers have hitherto been unaware of the facilities available to them.

It is of interest to notice also an increase in the number of enquiries received from dairymen and produce-retailers. This has been due, largely, although not entirely, to the contact made with the distributing side of the industry as a result of the course of lectures delivered to dairymen last autumn. Apart from this, however, there are signs of an increasing interest in improved methods amongst dairymen and, although no new bonus schemes have been initiated in the Province during the period under review, there is promise of at least one such scheme commencing in the near future.

(2) *Investigational Work.*

(*a*) Work continues on the methods employed in the examination of samples submitted in connection with the Register of Accredited Producers in Wiltshire. The new scheme of testing samples by the Reductase Test in combination with the Coliform Test in the 1/100th dilution only has been put into operation on an experimental basis, and the examination of a proportion of the samples received has been duplicated by the Plate Count

and full Coliform Test. It is hoped, when the full complement of samples to be submitted during the year has been received, to examine the figures obtained, and judgment of the scheme is reserved until these figures have been studied.

(*b*) The work on thermophillic organisms, which was begun at an earlier date and had to be suspended, has been recommenced and a considerable amount of preliminary work, in the nature of reviewing the literature and investigating methods of procedure, has been accomplished. It is hoped to proceed with this work as time permits.

(*c*) Arising out of an enquiry from a dairy company sterilising milk in Bristol, an interesting investigation is proceeding as to the cause of a coagulation of somewhat unusual type in the sterilised milk after heat treatment and storage. Although the original outbreak of this trouble was brief and not of very serious dimensions, several unusual features make it of particular interest both from the scientific and practical points of view.

(*d*) As indicated in the last annual report from this centre, there was some promise of a suitable opportunity occurring for an investigation into the possible origin of the Carbolic Taint Organism on the farm. Unfortunately, this opportunity has not materialised as the Somersetshire wholesalers, with whom it was hoped to co-operate, purchased the London company at the beginning of the season, and made radical changes both in methods of operating and source of supply of milk to the sterilising plant.

Agricultural Economics.

(1) *Enquiries and Advisory Work.*

The requirements of national economy necessitated some reorganisation of the programme of work in advisory economics, but attempts were made at the same time to keep in touch with as many farmers as possible although possibly in some directions not as closely as could have been desired. Reliance has, therefore, been placed during the past year upon surveys and enterprise studies, which have taken the place of several of the full cost accounts, and of a number of the simple financial accounts. Personal visits by the Advisory Economist and members of his staff have been made during the year as usual, and as far as funds permitted. Those farmers submitting their accounts for analysis

have received their individual reports, which contain indications of how management may be improved. The issue of group information in the shape of tables and pamphlets has been continued and has the effect of inducing the individual farmer to indulge in a certain amount of self-criticism in the light of economic results obtained over a group of farms of varying types.

Enquiries from farmers have tended to increase during the year. These take the form of enquiries upon simple points, such as the kind of farm account book to use to questions more complicated, such, for example, as the best means of investing a certain amount of capital in a new farm.

(2) *Investigational Work.*

Work of an investigational nature may conveniently be summed under the following heads :—

(*a*) *Costing.*

No. of Farms.	*Total Acreage.*
6	1,595

These may be classified as follows :—

Percentage of Permanent Grass.	*No. of Farms.*	*Type of Farm.*	
0 — 30%	1	Mixed	1
31 — 70%	1	Mixed	1
71 — 100%	4	Milk	2
		Milk and Cheese ..	1
		Mixed	1

(*b*) *Records and Costs of Experiments in Management.*

As from the middle of the year under report, a number of farmers have agreed to keep weekly records concerning the management of their dairy herds, but since the enquiry must be continued for a complete year, no results can yet be reported. It is anticipated, however, that it will then be possible to furnish useful information relating to variations in management as shown by milk yields in relation to types and quantities of foods consumed, and by the incidence and types of disease.

(*c*) *Financial Accounts.*

The simple financial account is being received from 190 farmers, and the following classification will give an indication of their type :—

No. of Farms.	*Total Acreage.*
190	74,500

These may be grouped as follows :—

Percentage of Permanent Grass.	*No. of Farms.*	*Type of Farm.*	
0 — 30%	14	Crops	2
		Mixed	12
31 — 70%	94	Cattle and Crops ..	17
		Mixed	36
		Crops and Sheep ..	10
		Milk	18
		Intensive Mixed ..	3
		Cattle and Sheep ..	2
		Sheep	2
		Crops and Pigs ..	2
		Pigs and Cheese ..	1
		Milk and Sheep ..	3

Percentage of Permanent Grass.	*No. of Farms.*	*Tyde of Farm.*	
71 — 100%	82	Milk	47
		Cheese	9
		Milk and Sheep ..	9
		Mixed	12
		Pigs and Cattle ..	4
		Cattle	1
Total ..	190		

(*d*) *Agricultural Surveys.*

(1) In January 1932, a survey was made of strawberry growing in the Cheddar Valley, Somerset. This was undertaken as a preliminary to the collection of cost account data. A report upon the position of the strawberry growing industry has been published.

(2) In July 1932, a survey of the willow growing industry of Somerset was carried out. The area surveyed is a compact one measuring nine miles by seven, and the growing of bush willows and their preparation for market constitute the chief sources of income for the bulk of the population in this district. The results of the survey are being embodied in a report to be issued by the department.

(*e*) *Special Investigations.*

(1) The modified scheme of ascertaining the cost of production of sugar beet on 20 farms in Herefordshire and Worcestershire has been continued. The costs so computed have been communicated to the farmers co-operating.

(2) The investigation into the cost of production of strawberries, referred to above and in the report for the previous year is being continued. The chief areas furnishing cost account data are parts of Herefordshire and Worcestershire as well as the Cheddar Valley of Somerset, which has already been mentioned.

(3) The special investigations into the application of statistical method to farm account data have been continued, and new lines of approach are being developed. The results are issued from time to time as a mimeographed bulletin.

Veterinary Science.

During the year under review 290 requests for advice were received, 512 pathological specimens received in the laboratory and 85 advisory visits paid.

Poultry diseases have demanded increasing attention during the year, and it is anticipated that this branch will require more attention in the future. Advice has been mainly conveyed by letter.

Press articles have also been employed, particularly with regard to Liver Rot which proved so serious last spring.

Co-operation with many practitioners in the Province has been firmly established. On several occasions the services of the Adviser have been sought, especially with regard to diseases of sheep and poultry. Valuable help has again been received from the Institute of Animal Pathology, University of Cambridge, during the year. The Adviser wishes to express his appreciation for the help received from the recently appointed Poultry Pathologist. It is anticipated that his services will be much in demand during the spring of next year.

Investigational.

Vaccination of lambs against contagious pustular dermatitis has been carried out on one farm. The strain of virus on this farm was found to be more virulent than is usual, so that while the vaccine did not completely protect against infection there was a pronounced moderating influence on the course of the disease.

A survey of the infestation of sheep with parasitic worms, as revealed by the egg counts, has been carried out on a few farms.

Jöhnin tests have been performed where Jöhne's Disease was particularly rampant in an effort to detect non-clinical cases of the disease.

Survey and Intelligence.

Sheep. Liver Rot of sheep has been exceptionally serious following the wet summer of 1931 and several cases where cattle were affected were encountered. Cases of death among in-lamb and recently lambed ewes were met with and inflation of the udder resorted to with considerable success where the symptoms of illness followed lambing. Among lambs, Lamb Dysentery caused losses which were successfully checked by the use of anti-serum. Several outbreaks of Parasitic Gastritis have occurred in the Province and the usual remedial measures adopted.

Cattle. Epizootic Abortion and its sequelae causes considerable loss in the Province, and has been the subject of many enquiries. Advice has been given and measures taken against this disease in consultation with the local practitioner.

Jöhne's Disease is very prevalent and requests for advice concerning it are on the increase. Many farms visited possessed a most unhygienic water supply, which in many cases is being reconstructed.

Pigs. Anaemia of young pigs is still a source of considerable loss to the pig breeder. Farrowing in the open has always been successful in preventing the occurrence of symptoms, but this system is not always practicable.

Poultry. Fowl paralysis appears to be spreading rapidly, and this increase is viewed with grave concern by the poultry keepers of the Province, especially as so little can be done in the way of remedial measures.

Tuberculosis, coccidiosis and dietetic errors have all been encountered during the year.

Bacillary White Diarrhoea was commonly found to be the cause of death of chicks.

Cider and Other Fruit Products.

615 enquiries, including 208 under the Cider Instruction Scheme in the counties of Dorset, Monmouth and Worcestershire, were dealt with during the year.

The general advisory enquiries entailed the analyses of 88 samples of ciders and perries and of several samples of dried pomace ; 79 estimations of alcohol were made, and several determinations of sulphur dioxide were necessitated.

The National Mark Scheme for cider has continued to provide numerous enquiries, whilst the utilisation of cull fruit from commercial orchards for cider making has again been an important subject of enquiry.

The number of enquiries relating to fruit products other than cider shows a substantial increase, and there appears to be a growing interest in such products. The main subjects of enquiry under this head were : the commercial preparation and marketing of non-alcoholic fruit juices, concentrated apple juice and fruit wines—loganberry wine in particular ; the use of enzymes for the clarification of fruit juices ; and the utilisation of dried apple pomace and pectin products.

The county of Dorset withdrew from the Cider Instruction Scheme at the end of March 1932, so that from that date the Instructor has been concerned only with the counties of Monmouth

and Worcester. He has paid special attention during the year to the following points :—

Bottling of Cider. Experiments were continued on farms in all the three counties concerned, attention being given to general points in connection with the production of high-grade bottled ciders, and to the special features of " disgorging " and pasteurization.

In Monmouth, in collaboration with the County Officers, demonstrations in the production of bottled ciders were given with the aid of the new cider plant recently installed at the Usk Institute.

Filtering. Demonstrations of filtering have been continued and are resulting in the growth of the practice in the areas.

Orcharding. During the summer months much advisory work on orcharding was carried out with the special objects of improving orchard practices and of stimulating the planting of orchards of useful varieties. This aspect of the work is of great importance at the present time, since many of the older orchards are gradually dying out, and there is a shortage of young plantings to meet the present requirements of the industry.

Pomology.

346 enquiries were received, including 150 from areas outside of the Province.

The subjects of enquiry related to many aspects of fruit production among which the following were prominent : the planting of cider orchards and problems relating to the propagation of cider trees ; the establishment of soft fruit plantations, and especially the suitabilities of varieties for canning purposes and problems relating to strawberry, black currant and blackberry culture ; miscellaneous problems in connection with the propagation of root stocks, pollination, pruning, cultural methods, bark ringing, head working of established trees, etc.

The character of the enquiries clearly indicates a renewed interest in the various branches of fruit growing, due to the changed fiscal policy of the country.

The pomological survey in progress in the Evesham-Pershore area has been actively continued and is practically completed.

Horticultural Chemistry.

123 enquiries, including 53 from sources outside of the Province, were received.

Special investigations were continued as follows :—

(1) Field Experiments on the Manuring of Fruit Trees and Bush Fruits.

a. Effect of Potash on Leaf Scorch (Experiments continued)—in Worcester and Hereford.

b. Effect of Potash and Lime on Leaf Scorch on an acid soil (Experiments continued)—in Worcester.

All the experiments above were concluded during the season and in every case the results show that potash manures are efficacious against leaf scorch under the varied conditions of the experiments. It is hoped that the results will be fully written up during the course of the present winter.

In certain of the cases the plots are being utilised to supply fruit for storage tests in which the effect of potassium starvation on keeping quality is under investigation.

(2) Experiments on the Control of Lime-induced Chlorosis in Apples, Pears and Garden crops—in Somerset and Worcester.

Further experiments were arranged during the year in which the effects of certain methods of injection of iron salts into trees will be studied. At one centre the effects will be compared with " grassing " treatment.

An attempt will be made to control chlorosis in garden crops by means of applying iron salts to the soil.

(3) Survey of Soils in fruit and Market Gardens on the Lower Lias Formation.

The survey work on the soils of the Evesham Vale has been completed and a map is in course of preparation showing soil series and textures, for an area of approximately 100 square miles. Work had been commenced on the Lias areas in Somerset.

The pomological work has been continued and it is hoped that during the next few months it will be possible to present a full report on the soils and pomology of the Evesham and Pershore areas.

Economic Entomology.

The number of enquiries received was 564, which shows an increase of 212 over last year. Personal visits totalled 145. A large number of enquiries concerned the control of the Apple Sawfly, the Raspberry Beetle and Red Spider.

The following is a summary of the principal investigations carried out during the year :—

Apple Sawfly (Hoplocampa testudinea).

Experiments in the 1932 season confirmed the results of last year in that the highest control of the pest is obtained on the variety Worcester Pearmain by the application of a nicotine wash 5-8 days after petal fall. It appears that in some seasons the wash may be applied as late as 12 days after petal fall without any serious reduction in the control obtained. Derris emulsion, ground derris root in a soap suspension, Pyrethrum emulsion and colloidal lead arsenate were also tested, the derris emulsion giving results equal to the nicotine wash. The other washes gave inferior results but nevertheless doubled the crop of fruitlets. The critical period for the application of washes on other varieties of apples is under investigation.

Apple Sawfly and Apple Scab.

A post blossom mixed wash consisting of lime-sulphur and nicotine, when activated by means of a suitable wetter and applied to the variety Worcester Pearmain, gave a satisfactory control of Apple Scab and the Apple Sawfly.

Mixed Summer Washes for the Control of Apple Scab and Insect Pests.

A mineral oil emulsion compatible with lime-sulphur was prepared. Preliminary experiments gave encouraging results, both as regards the degree of control obtained over the pests and the freedom from any serious bud and foliage damage.

The Control of the Raspberry and Loganberry Beetle.

An extensive range of Pyrethrum and derris washes and dusts of known toxicity were tested. A high control of the larvae was obtained by means of a derris wash which provided, at a much lower cost, results superior to those obtained from the application of Pyrethrum emulsions. One application of a barium silicofluoride wash gave promising results. It is evident in some seasons that the adult beetle attack should be checked in order to reduce the loss of berries at the beginning of the picking season.

" Lithiasis " of Pears.

It was found that the markings on pears, known as " Lithiasis," may be caused by the feeding on the fruits of the capsids *Plesiocoris rugicollis* and *Lygus pabulinus*.

Late Capsid Markings on Apples.

Experiments carried out under field conditions were somewhat inconclusive, but it was shown that " pit markings " are produced on the variety Lane's Prince Albert by *Lygus pabulinus*. The variety Worcester Pearmain was not affected in this way.

The Control of the Greenhouse Symphylid (Scutigerella immaculata).

Experiments on the control of this serious tomato pest showed that excellent results can be obtained by means of steam sterilisation, provided that the pest is attracted to the top layer of the soil before the treatment commences.

The Control of the Willow Beetle (Phyllodecta vitellinae).

Critical experiments were carried out on the toxicity of a derris dust of known rotenone content. A very high kill of the beetles was obtained and in dry weather the dust acted as an efficient repellent for several days.

The Addition of Wetters to Lead Arsenate.

The optimum qualities of two wetting compounds, Agral I and Lethalate Wetting Preparation, to be added to a lead arsenate wash when applied to willows were determined. An excess of either wetter caused an appreciable reduction in the quantity of the arsenate that adhered to the foliage.

Economic Mycology.

The number of advisory letters despatched during the year was 335, compared with 331 last year.

The following is a summary of the chief diseases under investigation :—

Fruit. Die-backs of apple trees (associated with *Cytospora* sp.); fruit rots of apples, especially that due to *Gloeosporium album*; strawberry leaf spots and fruit spots.

Vegetables. " Halo blight " of dwarf beans (caused by *Bacterium Medicaginis* var. *phaseolicola*); wilt of runner beans; pea "sickness" (associated with *Heterodera schachtii* and certain fungi); leaf and pod spots and foot rots of peas; control of " white tip " of leeks; a *Fusarium* foot rot of leeks; tip rot of onions associated with *Botrytis*; mint rust (*Puccinia Menthae*); marrow mosaic; violet root rot and other diseases of asparagus; parsnip " canker "; and " ring spot " and *Botrytis* of lettuces.

Flowers. Freesia mosaic; control of black blotch of delphiniums (*Bacterium Delphinii*); foot rot of asters caused by *Fusaria*; brown canker of roses (*Diaporthe umbrina*).

Miscellaneous. Rusts of basket willows and their control; stump rot of basket willows; canker of cricket bat willows; hop diseases occurring in the Province and their control (downy mildew, nettlehead, mosaic, split leaf, chlorotic disease, etc.).

Disease Control Materials and Methods.

Exact data for the enquiries submitted under this heading are not available for the year, due to the illness of the officer in charge of the work.

The number and nature of the enquiries were, however, similar to the previous year, the requests emanating mainly from manufacturers of sprays and spray materials.

The main subjects were as follows :—

1. The sources of supply of materials suitable for making winter washes and the methods of preparing such washes.
2. The preparation, etc., of Pyrethrum spray fluids.

Domestic Preservation of Fruit and Vegetables.

The number of enquiries dealt with during the year was 224, this figure being exclusive of letters dealing with lectures and summer courses. The number was less than in the year 1930-31, but the decrease can be accounted for by the fact that between October, 1931, and April, 1932, a large number of classes were given all over England, and many people who hitherto wrote for information received direct instruction.

The main subjects of enquiry were as follows :—

The use of commercial pectins.

The use of domestic pressure cookers with particular reference to marmalade-making.

The preservation of mushrooms, tomatoes, runner beans and strawberries.

Beet sugar for preserving purposes.

The reasons and remedy for the non-setting of various jams, jellies and marmalades.

The home-canning of fruits and vegetables.

Lectures and Classes.

Between October 1931, and April 1932, two 3-day classes were arranged in eleven counties, under the auspices of the National Federation of Women's Institutes. Single lectures were given at

general courses held in three counties which included fruit preservation as a subject of interest. The June and July lectures were given for the New Health Society and for the National Federation of Women's Institutes at the Royal Agricultural Show. Judging was carried out at Produce Exhibitions in six counties. Attendance at such exhibitions led to a great deal of direct advisory work.

Summer Courses.

From the middle of July until the middle of September, four 10-day courses were held at the Royal Agricultural College, Cirencester. The maximum number of students was enrolled, but for various reasons several students cancelled their applications when it was too late to fill their places, and the number that actually attended was 58 out of a possible 64. Between 30 and 40 applications were refused for the first three courses.

General.

The work has been developing along the lines indicated in the Progress Report, 1926-31, published in the Report, 1931. The work is still mainly educational and will remain so until some means are available for relieving the instructress of the heavy teaching duties she has to undertake during the fruit season, the period when so much experimental work ought to be undertaken.

Willow Growing.

219 enquiries were received regarding problems connected with willow growing. The main subjects of enquiry were as follows :—

The control of insect and fungus attacks.
Cultural management of new and of old beds.
Problems relating to varieties to grow and soil conditions.
Problems connected with the cultivation of the cricket bat willow.

Field trials were carried out with the object of controlling fungus and insect pests, dusts being used in each case because of the easier and less expensive method of application involved when compared with the use of liquid sprays.

Copper dust compounds as fungicides were used successfully and excellent results obtained by the use of derris root preparations against the Willow Beetle.

The interest in the cultivation of cricket bat willows has resulted in an increase in the number of enquiries received on this subject.

Information was requested on soil suitability, set material, management of young trees and the disposal of willow timber. Problems of defects in timber such as "trap bark" and "stain" were investigated.

The Somerset County Council willow beds continue to serve a useful purpose. All the best varieties have again been sold for planting purposes.

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OGILVIE, L.

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ROY, G. T.

"A Bulletin for Somerset Farmers." (University Bulletin, No. 7, Part 1, 1925—1929, Feb. 1932).

CAMPDEN RESEARCH STATION.

ADAM, W. B.

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HIRST, F.

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HIRST, F. and ADAM, W. B.

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"The Canning of Green Peas." (Canners' Bulletin No. 5 of the Campden Fruit and Vegetable Preservation Research Station, June 1932).

"The use of Sugar Syrups in Fruit Canning." (Canners' Bulletin No. 2 revised, of the Campden Fruit and Vegetable Preservation Research Station, June 1932).